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AUTHOR	Hevel, David; Donovan, Roger
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ABSTRACT

This document is one of a series of modules in the Missouri Auto Mechanics Curriculum Guide, which is based on 144 basic auto mechanics competencies identified on the Missouri Auto Mechanics Competency Profile. The instructor's materials in this document are for a 14-unit secondary education course. The following units are included: (1) principles of electricity; (2) electrical circuit design; (3) testing and diagnosing electrical circuits; (4) battery diagnosis and service; (5) starting systems; (6) disassembling, inspecting, testing, and repairing starter systems; (7) charging system components; (8) charging system diagnosis and repair; (9) inspecting, repairing, and replacing charging system components; (10) identifying, diagnosing, and testing automotive lighting systems; (11) repairing and replacing automotive lighting system components; (12) automotive gauges, warning devices, and driver information systems; (13) horn and wiper/washer systems; and (14) miscellaneous automotive accessories. The document begins with explanations of how to use the curriculum guide, how and why student achievement of competencies is evaluated over several job sheets, and how the curriculum guide is packaged. Next is a table that associates individual instructional materials in the units with the competencies they teach. The instructional units include unit objectives, objectives specific to each lesson in the unit, references, information sheets or outlines, assignment sheets, job sheets, tests, and answers to tests. (CML)

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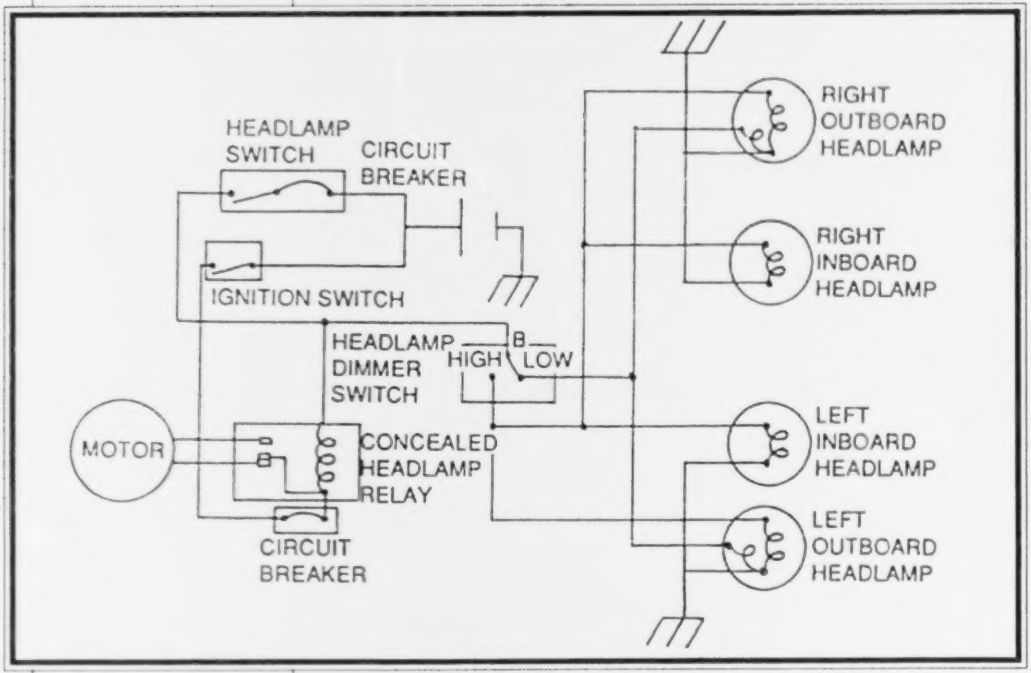
Instructor's Guide

Auto Mechanics
Curriculum Guide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Module 2
Electrical Systems

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MODULES INCLUDED IN THE AUTO MECHANICS CURRICULUM GUIDE

INTRODUCTION TO AUTO MECHANICS
ELECTRICAL SYSTEMS
ENGINE PERFORMANCE
ENGINE REPAIR
SUSPENSION AND STEERING
BRAKES
MANUAL DRIVE TRAIN AND AXLES
AUTOMATIC TRANSMISSION AND TRANSAXLES
HEATING AND AIR CONDITIONING

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AUTO MECHANICS CURRICULUM

MODULE 2: ELECTRICAL SYSTEMS

INSTRUCTOR'S GUIDE

Written by
David Hevel and Roger Donovan

Roger Donovan, Technical Advisor

Dana Tannehill, Editor and Project Coordinator

Produced by the Instructional Materials Laboratory
8 London Hall
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FOREWORD

Once again, we are indebted to the teachers and administrators who provide their time, efforts and professionalism to develop curriculum for trade, technical and industrial education programs. The Electrical Systems Module (the first of nine modules to make up the Missouri Auto Mechanics Curriculum Guide) is an outstanding example of what can be accomplished when the right people with the right attitude work together. The curriculum writers and subject matter experts who worked on this guide are to be commended for a job well done.

The module's format has been developed for competency-based teaching and testing. Job sheets within the guide evaluate specific competencies and can be managed with the Vocational Administrative Management System (VAMS). All major components of the module have been keyed to the auto mechanics competency profile, which was developed by industry and education professionals within Missouri.

Special appreciation is given to David Hevel, who was the primary writer for this module. Special appreciation is also given to Roger Donovan, who served as both a technical adviser and writer during production of the module.

The format and curriculum management system found in this module may be new to many vocational educators. However, we are confident that, when used as designed, this module will allow for more productive and rewarding educational experience for both teacher and student. Any future auto mechanics curriculum modifications will begin with the Missouri Auto Mechanics Curriculum Guide. Auto mechanics, like many technical fields, is undergoing constant and considerable change. We will annually evaluate the need to update this guide on a module-by-module basis. Your suggestions regarding areas for improvement are both encouraged and appreciated.

Judith Perryman, Supervisor
Industrial Education
Department of Elementary and Secondary Education

Charles Waibel, Director
Industrial Education
Department of Elementary and Secondary Education

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Electrical Systems is the second of nine modules, which make up the Missouri Auto Mechanics Curriculum Guide. Produced by the Instructional Materials Laboratory (IML), the guide represents a continuing commitment to Missouri's Vocational Instructional Management System (VIMS). All modules in the guide are based on the Missouri Auto Mechanics Competency Profile, which in turn is based on and cross-referenced to the ASE task list. For years ASE has set the professional standards for automotive technicians. Therefore, a strong ASE orientation makes the guide an effective tool for preparing students to enter the technologically advanced field of auto mechanics.

IML extends special recognition to David Hevel, the primary writer of Electrical Systems. Mr. Hevel's thorough knowledge of automotive technology and years of teaching experience are evident throughout his work. Special recognition also goes to Roger Donovan, who contributed heavily to the module, both as a writer and technical advisor. Mr. Donovan's attention to technical detail proved invaluable throughout the Module's development.

IML gratefully acknowledges the important contribution of the advisory committee, which, among other tasks, developed the competency profile for the guide. The advisory committee members are listed below:

Advisory Committee Members
Charles Waibel and Judith Perryman, Division of Vocational and Adult Education, Department of Elementary and Secondary Education, Jefferson City, Mo.
Robert Colesworthy, Lewis & Clark AVTS, St. Charles, Mo.
Richard Diklich, Longview Community College, Lee's Summit, Mo.
Ron Downing, Lamar AVTS, Lamar, Mo.
David Hevel, Hannibal AVTS, Hannibal, Mo.
Sam Smith, Chillicothe AVTS, Chillicothe, Mo.
Wayne Sweatt, Lake AVTS, Camdenton, Mo.
Darwin Kraenow, Linn Technical College, Linn, Mo.

IML also acknowledges the fieldtesters, who worked to ensure that the Electrical Systems Module was developed into an effective and practical teaching tool. The fieldtesters are listed below:

Fieldtesters
Robert Barbarick, Four Rivers AVTS, Washington, Mo.
Robert Colesworthy, Lewis & Clark AVTS, St. Charles, Mo.
Don Corbin, North Central AVTS, Bethany, Mo.
Richard Diklich, Longview Community College, Lee's Summit, Mo.
Ron Downing, Lamar AVTS, Lamar, Mo.
Gary Fiegley, Nevada AVTS, Nevada, Mo.
David Hevel, Hannibal AVTS, Hannibal, Mo.
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Instructional Materials Laboratory Staff
Harley Schlichting, Director
Amon Herd, Associate Director
Phyllis Miller, Assistant Director
Dan Stapleton, Assistant Director
Sharon Dyer, Graphic Artist II
Lori Holliday, Word Processor
Wei Li, Graduate Assistant

MODULE: ELECTRICAL SYSTEMS
CROSS-REFERENCE TABLE OF INSTRUCTIONAL MATERIALS

Competency	Instructional Objective	Assignment Sheet	Job Sheet	Test Item	Notes
All Competencies in Electrical Module	UI-L1-I, UI-L1-II, UI-LI-III, UI-L1-IV; UI-L2-I, UI-L2-II, UII-L1-I, UII-L1-III, UII-L1-IV, UII-L1-V	AS1-L1-UI AS1-L1-UII		UI 1-39 UII 1-50	
D1	UIII-L1-I, UIII-L1-II; UIII-L2-I, UIII-L2-II, UIII-L2-III; UIII-L3-I, UIII-L3-II-d, UIII-L3-II-f, UIII-L3-II-k		JS4-L3-UIII JS6-L3-UIII JS11-L3-UIII	UIII 1-37 UIII 38-45	
D2	UIII-L1-I, UIII-LI-II; UIII-L2-I, UIII-L2-II, UIII-L2-III; UIII-L3-I, UIII-L3-II-e, UIII-L3-II-g, UIII-L3-II-k; UIV-L2-III-f		JS5-L3-UIII JS7-L3-UIII JS11-L3-UIII JS6-L2-UIV	UIII 1-37 UIII 38-45	
D3	UIII-L1-I, UIII-L1-II; UIII-L2-I, UIII-L2-II, UIII-L2-III; UIII-L3-I, UIII-L3-II-b, UIII-L3-II-h, UIII-L3-II-k		JS2-L3-UIII JS8-L3-UIII JS11-L3-UIII	UIII 1-37 UIII 38-45	
D4	UIII-L1-I, UIII-L1-II; UIII-L2-I, UIII-L2-II, UIII-L2-III; UIII-L3-I, UIII-L3-II-a, UIII-L3-II-i		JS1-L3-UIII JS9-L3-UIII	UIII 1-37 UIII 38-45	
D5	UIII-L1-I, UIII-L1-II; UIII-L2-I, UIII-L2-II, UIII-L2-III; UIII-L3-I, UIII-L3-II-c, UIII-L3-II-j		JS3-L3-UIII JS10-L3-UIII	UIII 1-37 UIII 38-45	
E1	UIV-L1-I, UIV-L1-II, UIV-L1-III, UIV-L1-IV, UIV-L1-V; UIV-L2-III-b; UIV-L3-I		JS2-L2-UIV	UIV 1-20 UIV 21-25	
E2	UIV-L1-I, UIV-L1-II, UIV-L1-III; UIV-L2-I, UIV-L2-II, UIV-L2-III-a, UIV-L2-III-c, UIV-L2-III-d, UIV-L2-III-e; UIV-L3-I	AS1-L3-UIV	JS1-L2-UIV JS3-L2-UIV JS4-L2-UIV JS5-L2-UIV	UIV 1-20 UIV 26-41	

Competency	Instructional Objective	Assignment Sheet	Job Sheet	Test Item	Notes
E3	UIV-L1-I, UIV-LI-11,UIV-L1-III; UIV-L3-I, UIV-L3-IV, UIV-L3-V-b		JS2-L3-UIV	UIV I-20 UIV 49-51	
E4	UIV-L1-I, UIV-L1-II, UIV-L1-III; UIV-L3-I, UIV-L3-II, UIV-L3-III, UIV-L3-V-a		JS1-L3-UIV	UIV 1-20 UIV 42-48	
F1	UV-L1-I, UV-L1-II, UV-L1-III; UVI-L1-1, UVI-L1-II,UVI-L1-III UVI-L1-IV-a; UVI-L2-V-c	AS1-L1-UV	JS1-L1-UVI JS3-L2-UVI	UV Test UVI 1-17	
F2	UV-L1-I, UV-L1-II, UV-L1-III; UVI-L2-I, UVI-L2-II, UVI-L2-III, UVI-L2-IV, UVI-L2-V-a, UVI-L2-V-b	AS1-L2-UII AS2-L2-UVI	JS1-L2-UVI JS2-L2-UVI	UV Test UVI 18-24	
F3	UV-L1-I, UV-L1-II, UV-L1-III; UVI-L2-III, UVI-L2-V-d, UVI-L2-V-e	AS3-L2-UVI	JS4-L2-UVI JS5-L2-UVI	UV Test UVI 18-24	
G1	UVII-L1-I, UVII-L1-II, UVII-L1-III, UVII-L1-IV; UVIII-L1-I, UVIII-L1-II, UVIII-L1-III-a, UVIII-L1-III-b, UVIII-L1-III-c, UVIII-L1-III-d, UVIII-L1-III-e, UVIII-L1-III-f	AS1-L1-UVII	JS1-L1-UVIII JS2-L1-UVIII JS3-L1-UVIII JS4-L1-UVIII JS5-L1-UVIII JS6-L1-UVIII	UVII Test UVIII Test UIX Test	
G2	UVII-LI-I, UVII-L1-II, UVII-L1-III, UVII-L1-IV, UIX-L1-I, UIX-L1-II, UIX-L1-III, UIX-L1-IV-a	AS1-L1-UIX	JS1-L1-UIX	UVII Test UIX Test	
G3	UVII-LI-I, UVII-L1-II, UVII-L1-III, UVII-L1-IV, UIX-L1-I, UIX-L1-II, UIX-L1-III, UIX-L1-IV-b	AS2-L1-UIX	JS2-LI-UIX	UVII Test UIX Test	
G4	UVII-LI-I, UVII-L1-II, UVII-L1-III, UVII-LI-IV; UVIII-L1-I, UVIII-LI-III-a UIX-L1-II		JS-L1-UVIII	UVII Test UVIII Test UIX Test	

Competency	Instructional Objective	Assignment Sheet	Job Sheet	Test Item	Notes
H1	UX-L1-I, UX-L1-II, UX-L1-III, UX-L2-I, UX-L2-II, UX-L2-III-a, UX-L2-III-b	AS1-L2-UX	JS1-L2-UX JS2-L2-UX	UX 1-25 UX 26-40	
H2	UX-L1-I, UX-L1-II, UX-L1-III; UXI-L1-I, UXI-L1-II, UXI-L1-III-a	AS1-L1-UXI	JS1-L1-UXI	UX 1-25 UX 26-40	
I1	UXII-L1-I, UXII-L1-II, UXII-L1-III, UXII-L1-IV, UXII-L1-V, UXII-L1-VI-a UXII-L1-VI-b, UXII-L1-VI-c	AS1-L1-UXII AS2-L1-UXII AS3-LI-UXII	JS1-L1-UXII JS2-LI-UXII JS3-L1-UXII	UXII Test	
I2	UXIII-L1-I, UXIII-L1-II, UXIII-L1-III, UXIII-L1-IV, UXIII-L1-V, UXIII-L1-VI-a, UXIII-L1-VI-b, UXIII-L1-VI-c; UXIV-L1-I, UXIV-L1-II, UXIV-L2-I, UXIV-L2-II-a, UXIV-L2-II-b, UXIV-L2-II-c	AS1-L1-UXIII AS2-L1-UXIII AS3-L1-UXIII AS1-L2-UXIV AS2-L2-UXIV	JS1-L1-UXIII JS2-L1-UXIII JS3-L1-UXIII JS1-L2-UXIV JS2-L2-UXIV JS3-L2-UXIV	UXIII Test UXIV Test	

HOW TO USE THE MISSOURI AUTO MECHANICS CURRICULUM GUIDE

Every module of the Missouri Auto Mechanics Curriculum Guide contains the following seven major components: (1) a competency profile, (2) objective sheets, (3) information sheets, (4) assignment sheets, (5) tests, (6) job sheets, and (7) a cross-reference table. Below is a discussion of the design of these components.

MISSOURI COMPETENCY PROFILE

The competency profile identifies 144 basic auto mechanics competencies. The profile divides the competencies into nine general areas, each of which serves as the basis for individual modules of instruction (such as the Electrical Systems Module). The competency profile further divides these general areas into duty bands, each of which is identified by a capital letter. An example of a duty band in the Electrical Systems Module would be "Battery Diagnosis and Service." Under each duty band are listed several competencies, each of which is identified by an Arabic numeral. Note the below excerpt from the competency profile:

3	2	1	N	E. Battery Diagnosis and Service	ASE Task(s)
				1 Clean and inspect battery clamps, cables, and connectors	F011
				2. Perform battery condition tests	F008 F010
				3. Jump start a vehicle	F014
				4 Charge and install a battery	F012 F013

3	2	1	N	F. Starting System Diagnosis and Repair	ASE Task(s)
				1 Diagnose starting system and determine needed repair	F015 F016
				2. Remove, clean, and inspect starter motor and components	F017 F018 F019
				3 Repair or replace starter motor components	F020-F026

In this excerpt, the duty band "Battery Diagnosis and Service" is identified by the letter "E." The competency "Clean and inspect battery clamps, cables, and connectors" falls under Duty Band E and is identified by the Arabic numeral "1." Throughout the Auto Mechanics Curriculum Guide, therefore, the competency "Clean and inspect battery clamps, cables, and connectors" will be referred to as Competency E1.

Also note that one or more ASE tasks are listed to the right side of each competency on the profile. These ASE tasks are directly related to those competencies by which the tasks appear.

(**NOTE**: The term "cross-reference table" will appear throughout the rest of this discussion. A cross-reference table is a chart that shows precisely how objectives, assignment sheets, test questions, and job sheets are related to individual competencies. The cross-reference table will be discussed later in more detail.)

INFORMATION SHEETS

The information sheets (or information outline) present the student with important facts and concepts relating to basic automotive technology and service procedures. The information sheets also explain why a procedure is necessary and why it must be performed in a certain manner. Though not intended to be as comprehensive as a text book, the information sheets provide a good source of information, to which the student can refer outside of class. Perhaps the information sheets can best be thought of as a thorough set of notes accompanying the instructor's classroom lecture.

CONTENTS OF THE ELECTRICAL SYSTEMS MODULE

UNIT I: PRINCIPLES OF ELECTRICITY . . . . ES 1

UNIT II: ELECTRICAL CIRCUIT DESIGN . . . . ES 41

UNIT III: TESTING AND DIAGNOSING ELECTRICAL CIRCUITS . . . . ES 75

UNIT IV: BATTERY DIAGNOSIS AND SERVICE . . . . ES 145

UNIT V: STARTING SYSTEMS . . . . ES 219

UNIT VI: DISASSEMBLING, INSPECTING, TESTING, AND REPAIRING STARTER SYSTEMS . . . . ES 251

UNIT VII: CHARGING SYSTEM COMPONENTS . . . . ES 307

UNIT VIII: CHARGING SYSTEM DIAGNOSIS AND REPAIR . . . . ES 337

UNIT IX: INSPECTING, REPAIRING, AND REPLACING CHARGING SYSTEM COMPONENTS . . . . ES 377

UNIT X: IDENTIFYING, DIAGNOSING, AND TESTING AUTOMOTIVE LIGHTING SYSTEMS . . . . ES 407

UNIT XI: REPAIRING AND REPLACING AUTOMOTIVE LIGHTING SYSTEM COMPONENTS . . . . ES 461

UNIT XII: AUTOMOTIVE GAUGES, WARNING DEVICES, AND DRIVER INFORMATION SYSTEMS . . . . ES 483

UNIT XIII: THE HORN AND WIPER/WASHER SYSTEMS . . . . ES 527

UNIT XIV: MISCELLANEOUS AUTOMOTIVE ACCESSORIES . . . . ES 569

ASSIGNMENT SHEETS

The assignment sheets serve one of two functions: they can either emphasize important cognitive information or instruct students in developing procedures specific to a particular vehicle. The "Notes to the Instructor," found on the table of contents section of each module, identifies how each assignment sheet is used.

(**NOTE:** Assignment sheets are not used to evaluate competencies directly. Only job sheets directly evaluate competencies.)

UNIT TESTS

Unit tests cover information relating to specific competencies. The student must obtain an acceptable score (decided upon by the instructor) before receiving an evaluation for these competencies. (Since job sheets are used to evaluate competencies, the student, therefore, must receive an acceptable test score before doing certain job sheets.) The test ensures that the student has the minimum knowledge required to perform the competencies covered on the job sheets.

On some tests, all the questions cover information that relates equally to a single competency or a group of competencies . At the end of these tests, a note like the following appears:

> (NOTE: The student must obtain a minimum score of _____ on the Unit XII Test in order to receive an evaluation for Competency I1.)

Listed on the module's cross-reference table are all the job sheets related to Competency I1. After locating Competency I1 on the cross-reference table, the instructor can quickly determine what job sheets the student is eligible to do as a result of his or her test score.

On other tests, one group of questions covers information related exclusively to one particular competency while another group of questions relates exclusively to another particular competency. Questions relating to an individual competency (or a group of specific competencies) are divided into sections. At the end of each section, a note like the following appears:

> (NOTE: The student must obtain a minimum score of _____ on the Unit VIII Test in order to receive an evaluation for Competencies G1 and G4.)

Again, a quick look at the cross-reference table will reveal what job sheets a student is eligible to do as a result of his or her score on a particular section of a test.

The beginning units of a module often deal with basic knowledge that relates generally to all competencies in a module. The tests for these units will have notes stating that the student must obtain a certain score before performing any competencies in the module.

OBJECTIVE SHEETS

The first page of each unit in the guide is an objective sheet, which states the unit's general and specific objectives. Below is a portion of the objective sheet for Unit VIII of the Electrical Systems Module:

MODULE: ELECTRICAL SYSTEMS

UNIT VIII: CHARGING SYSTEM DIAGNOSIS AND REPAIR

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose and test a charging system. The student will demonstrate mastery of the material by achieving a score of ______ on the unit test.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1.
- I. Identify terms and definitions associated with charging system test procedures (Competencies G1 and G4, Unit VIII Test).
- II. Identify procedures for inspecting and testing charging system components (Competency G1, Unit VIII Test).
- III. Demonstrate the ability to:
  - a. Perform preliminary tests of the charging system and repair or replace charging system components (Competencies G1 and G4, JS1-L1-UVIII).
  - b. Perform an alternator output test (Competency G1, JS2-L1-UVIII).
  - c. Perform an alternator full-field test (Competency G1, JS3-L1-UVIII).
  - d. Perform a voltage regulator cutout test (Competency G1, JS4-L1-UVIII).
  - e. Perform a charging circuit resistance test (Competency G1, JS5-L1-UVIII).
  - f. Determine charging system requirements (Competency G1, JS6-L1-UVIII).

ASE TASKS COVERED IN THIS UNIT

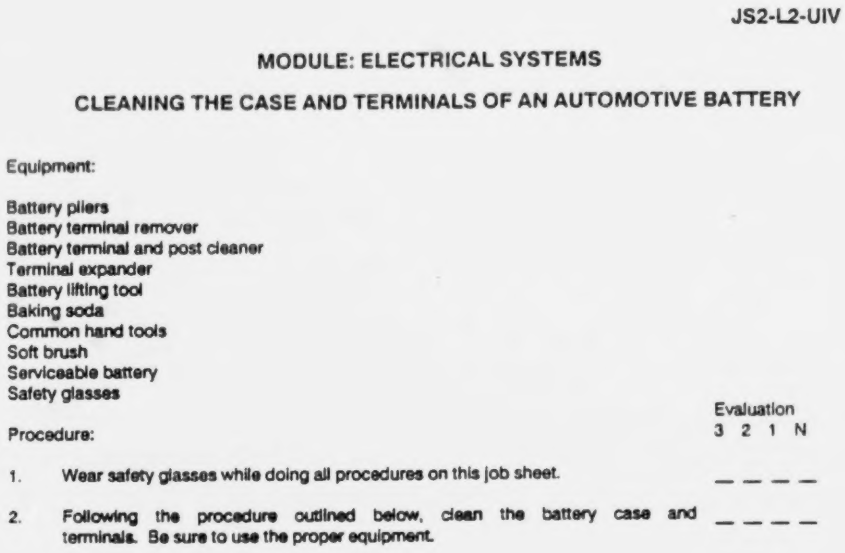
I. The job sheets in this unit cover ASE tasks F027-F032, F034, and F035. The job sheets can be adapted to cover ASE task F033.

Notice that the specific objectives are designated by Roman numerals. Also notice that the competency (or competencies) to which each objective relates is listed in parentheses behind each objective. Also listed in parentheses is the method by which the objective is evaluated.

A note identifying the ASE tasks that are covered by the unit's job sheets appears at the end of every objective sheet.

JOB SHEETS

Besides giving the student practical, hands-on experience in auto mechanics, job sheets provide a means of evaluating a student's ability to perform the competencies. The job sheets are, therefore, the key component of the Missouri Auto Mechanics Curriculum Guide. Below is an excerpt from the first page of a typical job sheet in the Electrical Systems Module:



JS2-L2-UIV

MODULE: ELECTRICAL SYSTEMS

CLEANING THE CASE AND TERMINALS OF AN AUTOMOTIVE BATTERY

Equipment:

Battery pliers
Battery terminal remover
Battery terminal and post cleaner
Terminal expander
Battery lifting tool
Baking soda
Common hand tools
Soft brush
Serviceable battery
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. _ _ _ _

2. Following the procedure outlined below, clean the battery case and terminals. Be sure to use the proper equipment. _ _ _ _

Notice that the job sheet is identified as JS2-L2-UIV, which translates into Job Sheet 2, Lesson 2, Unit IV. This shorthand system of job sheet identification is used throughout the curriculum guide.

(**NOTE:** Assignment sheets are identified with the same shorthand system. Assignment Sheet 1, Lesson 1, Unit X would be AS1-L1-UX.)

(**NOTE:** Both job sheets and assignment sheets are numbered consecutively within unit lessons.)

Also notice that, in the above job sheet excerpt, the spaces to the right of the page allow the instructor to evaluate the student on a particular job sheet activity. These spaces appear only by numbered items, which represent significant tasks; therefore, the instructor is freed from having to evaluate the minor steps of a procedure. At the beginning of each job sheet the heading "3 2 1 N" indicates the four possible evaluations a student can receive. The meaning of the numbers and the letter N is as follows:

3 = Mastery - can work independently with no supervision
2 = Requires supervision - can perform job completely with limited supervision
1 = Not mastered - requires instruction and close supervision
N = No exposure - no experience or knowledge in this area

The individual evaluations made throughout a job sheet are averaged together at the end of the job sheet. A note explains how this average relates to the final evaluation for a particular competency. In the below example taken from JS2-L3-UIV, a note explains that the average of individual evaluations (made throughout JS2-L3-UIV) is the final evaluation for Competency E3:

Average of above evaluations* ____

(*This is the final evaluation for Competency E3.)

As all automotive instructors know, an automobile contains many complex and interrelated components. A single general service task may involve several different procedures. In the Missouri Auto Mechanics Curriculum Guide, therefore, a competency may be evaluated over several job sheets; also one job sheet may evaluate several competencies. As will be demonstrated later, each job sheet is accompanied by a thorough set of instructions, explaining how each of the final job sheet averages is to be used. The cross-reference table is also quite helpful in showing which job sheets evaluate which competencies.

CROSS-REFERENCE TABLE

The cross-reference table can quickly reveal how competencies relate to instructional objectives, job sheets, and test items. Note the following excerpt from the Electricity Module cross-reference table in the Electrical Systems Module:

CROSS REFERENCE TABLE OF INSTRUCTIONAL MATERIALS

Competency	Instructional Objective	Assignment Sheet	Job Sheet	Test Item	Notes
E2	UIV-L1-I, UIV-L1-II, UIV-L1-III; UIV-L2-I, UIV-L2-II, UIV-L2-III-a, UIV-L2-III-c, UIV-L2-III-d, UIV-L2-III-e; UIV-L3-I	AS1-L3-UIV	JS1-L2-UIV JS3-L2-UIV JS4-L2-UIV JS5-L2-UIV	UIV 1-20 UIV 26-41	

The above excerpt reveals that Competency E2 is covered by Instructional Objectives I through III in Lesson 1 of Unit IV and Instructional Objectives I through IV in Lesson 2 of Unit IV. The cross-reference table also shows that questions 1 through 41 of the Unit IV test relate to Competency E2. Most importantly, however, the table reveals at a glance that the student must perform JS1-L2-UIV, JS3-L2-UIV, JS4-L2-UIV, and JS5-L2-UIV before he or she can receive an evaluation for Competency E2. By looking at the cross-reference table, the instructor can quickly determine what test questions a student needs to answer and what job sheets a student needs to perform before receiving a final evaluation for a particular competency.

HOW AND WHY COMPETENCIES ARE EVALUATED OVER SEVERAL JOB SHEETS

According to the competency profile, Competency E2 ("Perform Battery Condition Tests") covers ASE tasks F008-F010. These tasks are identified below:

F008-Determine battery state of charge test; determine service needed

F009-Perform battery capacity (load, high rate discharge) test; determine service needed

F010-Perform battery three-minute charge test; determine service needed

A job sheet covering all three of these ASE tasks would be unreasonably long and overly complicated. The Missouri Auto Mechanics Curriculum Guide allows the student to perform several job sheets in order to receive an evaluation on Competency E2. These job sheets are listed below:

JS1-L2-UIV:	CHECKING THE AUTOMOTIVE BATTERY FOR SURFACE LEAKAGE
JS3-L2-UIV:	MEASURING THE STATE OF CHARGE OF AN AUTOMOTIVE BATTERY
JS4-L2-UIV:	LOAD TESTING THE AUTOMOTIVE BATTERY
JS5-L2-UIV:	PERFORMING A THREE-MINUTE CHARGE TEST ON AN AUTOMOTIVE BATTERY

The activities in the above job sheets satisfy Missouri Competency E2 and the ASE tasks that accompany E2. At the end of each job sheet relating to E2, a note explains that the average of individual evaluations made throughout the job sheet is a partial evaluation for E2. The note also indicates on what job sheet the final evaluation for E2 will be determined. Below is an example of the note:

Average of above evaluations* __ __ __ __

(*This is a partial evaluation for Competency E2. Final evaluation for E2 will be made at the end of JS5-L2-UIV.)

At the end of JS5-L2-UIV, the following notes and directions explain how and where the final evaluation for E2 is to be made:

Average of above evaluations* ___ ___ ___ ___

(*This average is a partial evaluation for Competency E2. Final evaluation for E2 will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency E2 by averaging the final evaluations from JS1-L2-UIV, JS3-L2-UIV, JS4-L2-UIV, and JS5-L2-UIV. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS1-L2-UIV	___	___	___	___
JS3-L2-UIV	___	___	___	___
JS4-L2-UIV	___	___	___	___
JS5-L2-UIV	___	___	___	___
Final evaluation for Competency E2	___	___	___	___

Sometimes competencies are evaluated by job sheets appearing in different units. Consider Competency D2, "Check for shorts, opens, and grounds." According to the competency profile, the ASE tasks which relate to D2 are as follows:

F005-Find shorts and grounds in electrical circuits

F006-Diagnose the causes of constant battery drain

F007-Inspect test and replace fusible links, circuit breakers and fuses

Unit III explains how an electrical circuit works and how it is tested. ASE tasks F005 and F007 are, therefore, covered in Unit III. ASE task F006, however, deals with the battery and thus can best be covered in the battery unit, which is Unit IV. Competency D2, therefore, receives partial evaluation in JS5-L3-UIII, JS7-L3-UIII, and JS11-L3-UIII (all in Unit III) and final evaluation in JS6-L2-UIV (in Unit IV). At the end of all Unit III job sheets evaluating D2, the following note appears:

Average of above evaluations* ___ ___ ___ ___

(*This is a partial evaluation for Competency D2. Final evaluation for D2 will be made at the end of JS6-L2-UIV.)

At the end of JS6-L2-UIV, a similar note appears along with instructions for making a final evaluation for Competency D2:

Average of above evaluations* __ __ __ __

(*This average can include any or all of the evaluations of items 3 through 5 in this job sheet. This average is a partial evaluation for Competency D2. Final evaluation for D2 will be made below.)

JS6-L2-UIV

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency D2 by averaging the final evaluations from JS5-L3-UIII, JS7-L3-UIII, JS11-L3-UIII, and JS6-L2-UIV. Use the spaces provided below.

	Evaluation 3 2 1 N
JS5-L3-UIII	__ __ __ __
JS7-L3-UIII	__ __ __ __
JS11-L3-UIII	__ __ __ __
JS6-L2-UIV	__ __ __ __
Final evaluation for Competency D2	__ __ __ __

While most job sheet notes have the same basic form, some variations are necessary. For example, a job sheet such as JS11-L3-UIII ("Inspecting, Testing, and Replacing Fusible Links, Circuit Breakers, and Fuses") may evaluate several competencies. At the end of JS11-L3-UIII, the following note and evaluation instructions appear:

Average of above evaluations* ___ ___ ___ ___

(*This is a partial evaluation for Competencies D1, D2, and D3. Final evaluations for D1 and D3 will be made at the end of this job sheet. Final evaluation for Competency D2 will be made at the end of JS6-L2-UIV.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency D1 by averaging the final evaluations from JS4-L3-UIII, JS6-L3-UIII, and JS11-L3-UIII. Determine the student's final evaluation for Competency D3, by averaging the final evaluations from JS2-L3-UIII, JS8-L3-UIII, and JS11-L3-UIII. Use the spaces provided below.

		Evaluation			
		3	2	1	N
A.	Evaluating Competency D1				
	JS4-L3-UIII	___	___	___	___
	JS6-L3-UIII	___	___	___	___
	JS11-L3-UIII	___	___	___	___
	Final evaluation for Competency D1	___	___	___	___
B.	Evaluating Competency D3				
	JS2-L3-UIII	___	___	___	___
	JS8-L3-UIII	___	___	___	___
	JS11-L3-UIII	___	___	___	___
	Final evaluation for Competency D3	___	___	___	___

Though variations on job sheet notes are sometimes necessary, the information in the note is always presented in a straight-forward, easy-to-understand manner.

PACKAGING OF THE AUTO MECHANICS CURRICULUM GUIDE

Each module in the Auto Mechanics Curriculum Guide is packaged in three components: an instructor's guide, a student reference, and student work sheets. The instructor's guide includes the following items, all of which are color coded:

Cross-reference table (color-coded white)
Objective sheets (color-coded white)
Table of contents, references, notes to the instructor (color-coded pink)
Information sheets (color-coded green)
Assignment sheets (color-coded tan)
Job sheets (color-coded blue)
Unit tests (color-coded yellow)

The student reference contains copies of the objective sheets and information sheets from the instructor's guide. The student work sheets include consumable items from the instructor's guide, such as job sheets, assignment sheets, and unit tests. For convenience, the page numbers of the items in the student reference and in the work sheets are the same as those in the instructor's guide; therefore, page numbers in the student reference and work sheets are not consecutive. (Both the instructor's guide and the work sheets are color coded. All student reference pages, however, are white.)

Competency profiles for the guide are packaged in groups of ten along with a copy of the ASE task list.

MODULE: ELECTRICAL SYSTEMS

UNIT I: PRINCIPLES OF ELECTRICITY

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the fundamental principles of electricity and solve electrical problems using Ohm's law. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify terms and definitions associated with the principles of electricity (all competencies in the Electrical Systems Module, Unit I Test).

II. Identify the parts of the atom and the principles of electrical charges (all competencies in the Electrical Systems Module, Unit I Test).

III. Identify the fundamental principles of circuits and basic circuit components (all competencies in the Electrical Systems Module, Unit I Test).

IV. Identify various types of electron pumps and the principles by which they function (all competencies in the Electrical Systems Module, Unit I Test).

Lesson 2. I. Identify concepts relating to the ampere and the ohm (all competencies in the Electrical Systems Module, Unit I Test).

II. Identify principles of Ohm's law (all competencies in the Electrical Systems Module, Unit I Test).

ASE TASKS COVERED IN THIS UNIT

I. Only material that is preliminary to ASE tasks appears in this unit. No ASE tasks are covered directly.

MODULE: ELECTRICAL SYSTEMS

UNIT I: PRINCIPLES OF ELECTRICITY

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Unit I introduction

E. Information outline

    1. Lesson 1: ELECTRONS AND ELECTRICAL THEORY

        a. Information outline

    2. Lesson 2: ELECTRICAL MEASUREMENT AND OHM'S LAW

        a. Information outline

        b. Assignment sheets

            AS1-L2-UI: Solving Problems Using Ohm's Law

F. Unit test

G. Answers to unit test

REFERENCES

Battery Council International. Battery Service Manual. Chicago: Battery Council International, 1982.

Chrysler Motors. 1988 Service Manual: Electrical, Fuel, and Emission Systems: Front Wheel Drive Car.

Chrysler Motors. 1988 Service Manual: Engine, Chassis, and Body: Front Wheel Drive Car.

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Crouse, W.H. Automotive Electronics and Electrical Equipment. 10th ed. New York: McGraw-Hill Book Company, 1986.

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DeKryger, William, J., Robert T. Kovacik, and Saverio G. Bono. Auto Mechanics Theory and Service. Cincinnati: South-Western Publishing Company, 1986.

Derato, Frank. Electrical and Electronic Systems. New York: McGraw-Hill Book Company, 1986.

Derato, Frank. Electrical and Electronic Systems: Shop Manual. New York: McGraw-Hill Book Company, 1986.

Downing, Ronald. Automotive Electrical Systems and Tune-up Procedures: Instructor's Guide. Module 5 of Auto Mechanics. University of Missouri-Columbia: Instructional Materials Laboratory, 1981.

Mitchell Information Services, Inc. 1986 Domestic Cars Tune up Mechanical Service and Repair. San Diego: Mitchell Information Services, Inc., 1986.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit.

  1. Students should do AS1-L2-UI before taking the Unit I Test.

B. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

  1. Fire Safety in the Auto Shop (AM-80-110), 1980.
  2. Parts Cleaning: Safe Methods of Handling and Storage (AM-80-120), 1980.
  3. Auto Electrical Theory (AM-84-500), 1984.

MODULE: ELECTRICAL SYSTEMS

UNIT I INTRODUCTION

Electrical energy originates in the world of atoms. Atoms are so small that even a tiny speck of material contains billions of them. Atoms are composed of electrons, protons, and neutrons. The electrons orbit the nucleus. Certain types of force can cause the electrons in some materials to move from one atom to the next. This movement of electrons is electricity.

Electricity moves through some materials more easily than others. When electricity passes through a material that inhibits its flow, heat is produced. Electrical devices use this heat to do work. When a light bulb receives electrical current, billions and billions of electrons per second flow into and out of the bulb's filament. The electrons do not flow across the filament as easily as they flow across the wire leading to the bulb. Therefore, the atoms that are already on the filament have to give up heat energy in order to make room for the newly arrived electrons. The heat energy, in turn, causes the filament to glow.

An electrical circuit does not use up electrons. Instead electrons merely flow through a circuit in much the same way as liquid coolant flows through a car's radiator and engine block.

When a person receives an electrical shock, billions of electrons are forced into his or her body. At the same time, the atoms that make up that person's body pass electrons on, thus making that person part of an electrical circuit. Human beings can easily become part of an electrical circuit; therefore, working around electricity can be very dangerous. An electrical shock interferes with muscle function. If a person receives a great enough shock, the biggest muscle in his or her body--the heart--will stop. Under certain circumstances, a person can receive a dangerous shock or burn from an automobile's electrical system.

Understanding how electricity functions in the world of atoms is very important. The modern vehicle uses more electrical devices than ever before. Many of these devices are tiny, sensitive computers, which can be destroyed by improper use of electronic test equipment. Understanding the fundamentals of electricity will allow the technician to work with electrical circuits confidently and safely.

MODULE: ELECTRICAL SYSTEMS

UNIT I: PRINCIPLES OF ELECTRICITY

LESSON 1: ELECTRONS AND ELECTRICAL THEORY

I. Terms and definitions

A. Ampere--A unit of measure of electricity. One ampere (amp) is equal to 6.28 X 10 (18) (6,280,000,000,000,000,000) electrons passing a given point in a circuit in one second.

B. Atom--The smallest particle of any element.

C. Attraction--The force that pulls differently charged particles toward each other.

D. Conductor--Any material across which electricity can pass. A good conductor has an abundance of atoms with free electrons.

E. Circuit--A conductor through which electrons can flow away from and return to an electrical source.

F. Current--The flow of electrons.

G. Electrical control--A device that allows or prohibits current flow in a circuit.

H. Electrical load--A device that requires electrical current flow in order to operate. When the electrical load is working, it puts a "load" on the circuit.

I. Electrons--The negatively charged parts of an atom. Electrons orbit the nucleus.

J. Electron force--The force that pushes free electrons out of orbit, creating current flow in a circuit.

K. Electron pump--A device that provides electron force. Electron pumps can take a wide variety of forms. A nuclear power plant and a flashlight battery are both examples of electron pumps.

L. Free electron--An electron which has a weak attraction to the nucleus. (As was said above, electrons orbit the nucleus.) Because their attraction to the nucleus is weak, free electrons are easily passed from atom to atom.

M. Molecules--Atoms which have collected to form a larger particle. Atoms are the building blocks of molecules, and molecules are the building blocks of matter.

N. Nucleus--The center of an atom.

O. Ohm--A unit of electrical resistance in a circuit. One ohm is the amount of resistance that occurs when one volt of electricity forces one ampere through a circuit.

P. Ohm's law--A statement of the relationship between amps, ohms, and volts.

Q. Protons--The positively charged parts of an atom. The protons are located in the nucleus.

R. Repulsion--The force that pushes similarly charged particles away from each other.

S. Resistance--The ability of a material to restrict the flow of electricity. A material's resistance is determined by the property of its atoms.

T. Volts--A measure of electrical force in a circuit. One volt is defined as the amount of force needed to push one ampere of electricity through one ohm of resistance.

II. Molecular and atomic structure

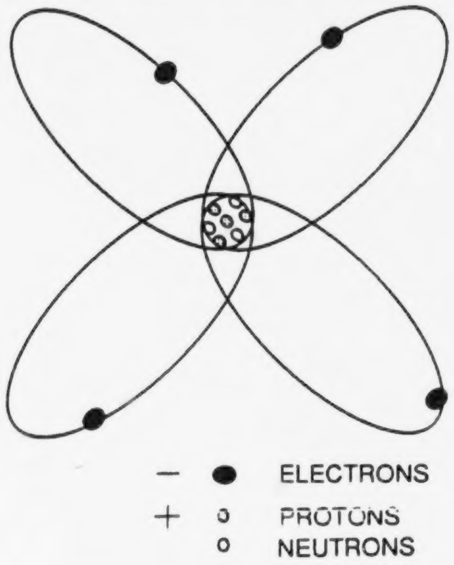
A. Everything large enough for us to see is actually a collection of very small particles called molecules. Molecules are made up of even smaller particles called atoms.

B. Atoms

1. Atoms are the building blocks of all matter. Atoms are so small that billions and billions of them are needed to make up a single drop of water. Atoms cannot be seen by the naked eye.

2. An atom is a carefully balanced energy machine. At its center is the nucleus, which contains protons and neutrons. Electrons rapidly orbit the outside of the nucleus.

AN ATOM SHOWING THE ELECTRONS, PROTONS, NEUTRONS AND THEIR RELATIVE MOTION

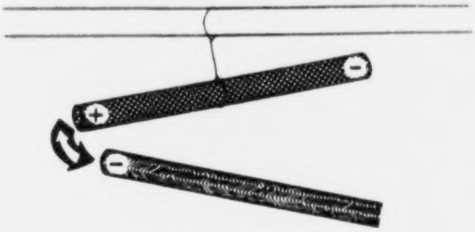


3. Even though electrons, neutrons, and protons are very tiny, they have weight and occupy space. The laws of nature, therefore, apply in the world of the atom in much the same way as they apply in the larger, visible world. Just as an automobile cannot be moved unless something pushes or pulls it, an electron cannot be moved unless some force acts upon it. The forces that work within the atom are called atomic forces.

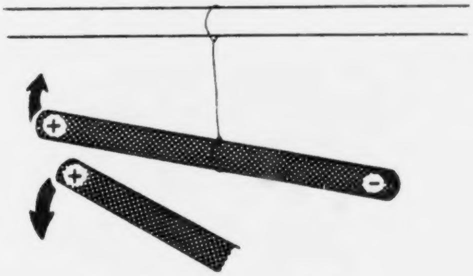
C. Attraction and repulsion (atomic forces)

1. Any two atomic particles that are both either positively or negatively charged will repel each other. On the other hand, if one atomic particle is positively charged and another is negatively charged, then the two particles will attract each other.

ATTRACTION AND REPULSION OF CHARGES

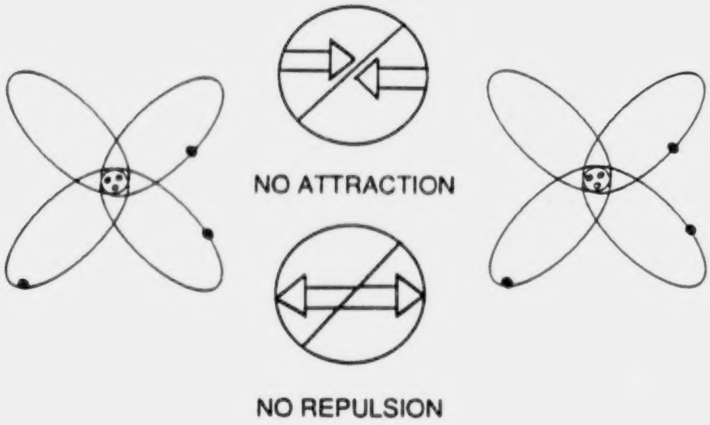


+ - CHARGES ATTRACT



+ + OR - - CHARGES REPEL

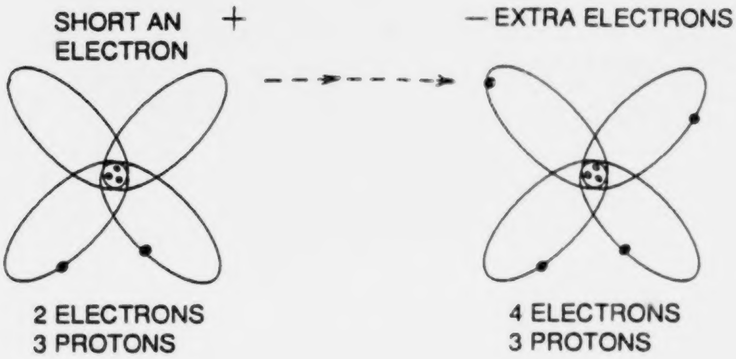
2. Because the electrons orbiting the atom are negatively charged (-), they are attracted to the positively charged (+) protons in the atom's nucleus. When an atom contains an equal number of protons and electrons, the forces of attraction and repulsion within the atom are balanced. The atom is, therefore, neutrally charged and will not be attracted to or repelled by any other atom.


NO ATTRACTION
NO REPULSION

D. Positive and negative charges

1. If an external force causes an electron (-) to depart from its orbit around a neutrally charged atom, the electron will leave behind a positively charged hole (+). This hole will upset the balance between positive and negative charges and thus make the atom positively charged.

2. The balance between positive and negative charges in a neutrally charged atom would also be upset if the atom were forced to accept an extra electron (-). The extra electron would make the atom negatively charged.


SHORT AN ELECTRON +
— EXTRA ELECTRONS
2 ELECTRONS
3 PROTONS
4 ELECTRONS
3 PROTONS

3. Any material will have the same state of charge as the atoms that make it up. If the majority of the atoms in a material are short an electron, that material will be positively charged. If the majority of the atoms in a material have an extra electron, that material will be negatively charged.

III. Circuits and basic circuit components

A. Electron movement

1. An atom that is short of electrons will attract new electrons. An atom that contains extra electrons will repel the extra electrons.

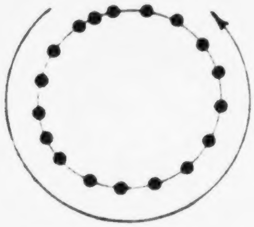
2. Electrons orbit the atom in layers called shells. In most of these shells, the electrons are tightly bound and cannot be dislodged. However, electrons can be dislodged from the outer shell of some atoms with the help of an external power source. The outer shell may also accept new electrons that are forced toward it.

3. The copper atom, for example, has only a single electron on its outer layer. This single electron (-) has a weak attraction to the proton (+) in the atom's nucleus; therefore, the electron can be easily dislodged from its orbit. The outer electron is said to be free, and the copper atom is said to be a good conductor of electrons.

4. Imagine that copper atoms are brought together to form a continuous loop so that their free outer electrons are close together. In this arrangement, all of the copper atoms have a balanced number of electrons and protons (that is they have a neutral charge). As long as no external power source is present, the electrons in the loop will not be attracted or repelled (with the exception of the electron's weak attraction to the proton within their own atom).

COPPER ATOMS IN A ROW

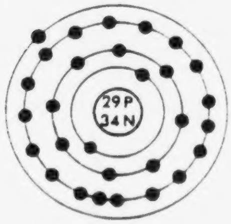
CONTINUOUS LOOP OF ATOMS

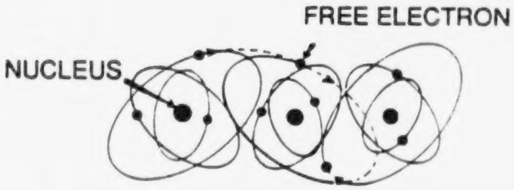


5. If some outside force causes one electron in the row of copper atoms to leave its orbit, that electron will begin to orbit the neighboring atom. The atom from which the electron was dislodged will become more positively charged (due to the absence of an electron). The atom around which the electron begins to orbit will become more negatively charged (due to its extra electron).

MOBILITY OF FREE ELECTRONS

A COPPER ATOM

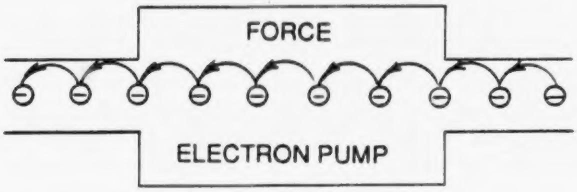




MOBILITY OF ELECTRONS

6. This movement of a single electron will begin a chain reaction. The atom that becomes positively charged (due to the movement of the electron) will begin to attract the free electron in the neighboring atom. The negatively charged atom will repel its new electron and push it to the next atom in the loop. Electrons will then be passed from atom to atom around the loop. This loop can, therefore, be called a circuit.

7. This chain reaction will continue as long as the outside force causes the electrons to move. When the force is removed, the atoms again become balanced and electron movement stops.



8. The movement of electrons is called current. Current can be converted into mechanical, thermal, or magnetic energy.

B. Electron pumps and loads

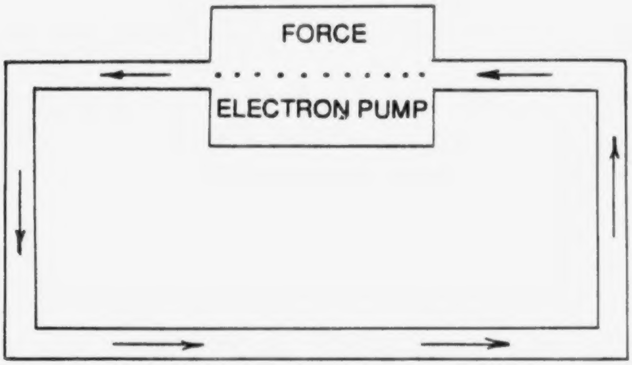
1. Electron pumps

   a. Before current can flow through a circuit, electrons must be forced to move. The device that produces this force can be thought of as a kind of electron pump that pulls electrons from one atom and forces them into the next.

   b. An electron pump forces electrons into one end of the circuit while pulling them out the other end. The electron pump moves electrons through a circuit much like a water pump moves liquid through an engine's cooling system.

   c. Electron pumps come in a variety of forms. A flashlight battery and a nuclear power plant are both examples of electron pumps.

      (NOTE: Electrons move at nearly the speed of light, 186,000 miles per second.)

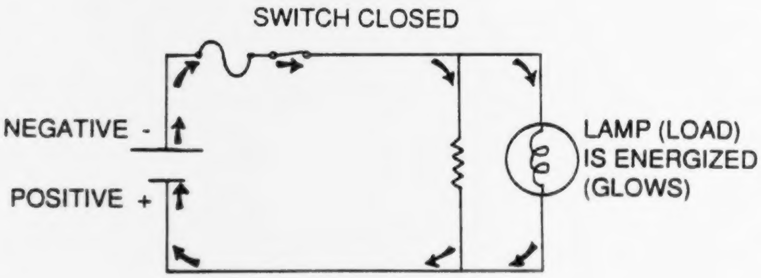


2. Loads

   a. Electrical devices contain components that provide resistance to electric current flow. This resistance will cause the current to produce mechanical, thermal, or magnetic energy, which, in turn, can be used to perform work. A component that provides resistance in an electrical circuit is called a load.

   b. One example of a load is the filament in a light bulb. Electrical current (electron flow) will be forced across the bulb's filament, which provides resistance. The heat produced as a result of this resistance will cause the filament to glow.

SCHEMATIC SHOWING CURRENT FLOW

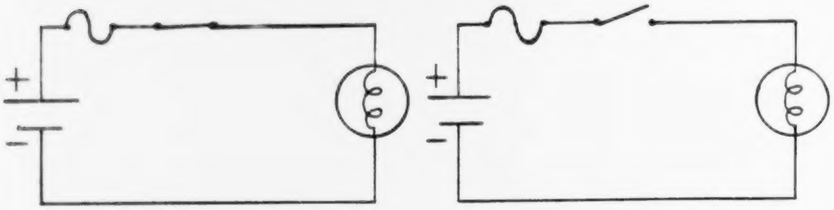


c. If more than one load device is connected in parallel across any part of a circuit, current flow in the circuit will be divided in proportion to the resistance of each of the parallel load devices.

C. Circuit controls and protection devices

1. Imagine a circuit in which a simple switch is used to control a light bulb (a load). When the switch is open, current flow will stop and the bulb will go out. When the switch is closed, current flow will resume and the bulb will come on.

SCHEMATICS SHOWING CIRCUIT ON - OFF CONDITION



CLOSED CIRCUIT
(CURRENT WILL FLOW)

OPEN CIRCUIT
(CURRENT CAN NOT FLOW)

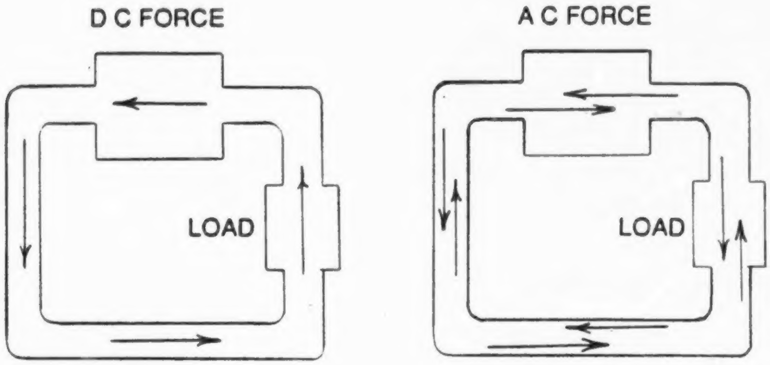
2. Safety devices (fuses, fusible links, or circuit breakers) within an electrical circuit are designed to open when the circuit is overloaded. Safety devices protect the circuit and its components.

D. AC and DC

1. The direction of electron flow within a circuit is important. In some circuits, the electron pump causes the electrons to flow in only one direction. These circuits are called direct current (DC) circuits.

2. In other circuits, electron pumps move the electrons in alternate directions. These circuits are called alternating current (AC) circuits.

3. There are advantages and disadvantages to both AC and DC circuits. DC circuits are used more often in automobiles than are AC circuits.



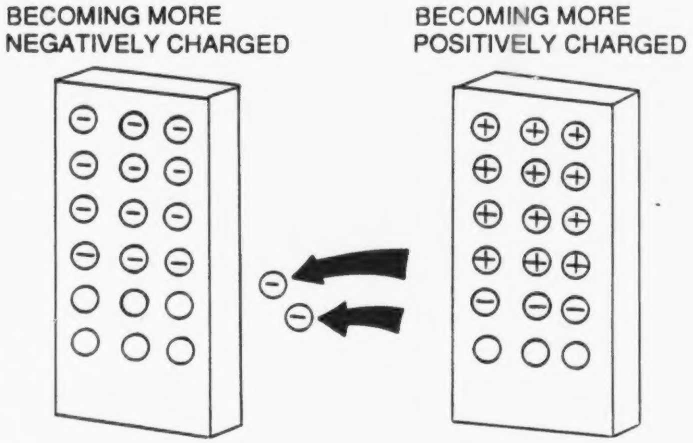
IV. All electron pumps produce current by one of the following methods: (1) the application of potential difference; (2) the use of a magnetic field; (3) the use of thermal energy; (4) and the use of a crystal.

A. The principle of potential difference

1. The principle of potential difference operates when one side of a circuit has more electrons than the other side. The excess electrons will flow through the circuit to the side with fewer electrons.

2. If free electrons are dislodged from a conductive material, then that material will no longer maintain a neutral charge. The loss of electrons will cause the material to become positively charged (+). The more electrons removed from the material, the stronger the material's attraction for new electrons will become.

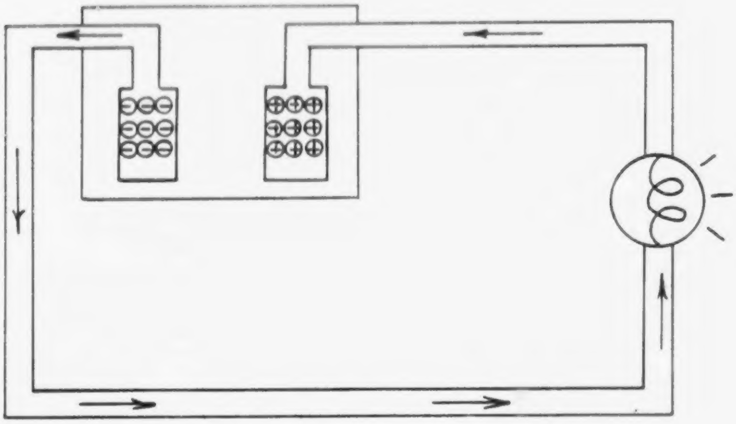
3. If the free electrons from the first conductive material are collected and forced into orbit around the atoms of a second conductive material, the second material will become negatively (-) charged and tend to repel the extra electrons.


BECOMING MORE NEGATIVELY CHARGED
BECOMING MORE POSITIVELY CHARGED

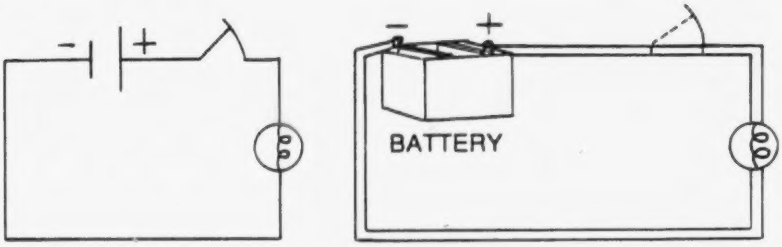
4. In the first conductive material, the number of electrons will increase. In the second conductive material, the number will decrease. The first material will, therefore, develop an increasingly strong negative charge. The second material will develop an increasingly strong positive charge.

5. A potential difference device contains both positively charged and negatively charged materials. If a potential difference device is placed in a circuit, extra electrons from the positively charged material will flow through the circuit to the negatively charged material. While the electrons are flowing, the electrical circuit is live and can perform work. When all the electrons have returned to the positively charged material, electron flow will cease.

   (NOTE: The strength of the current flow will depend on the strength of the negative and positive charges in the two materials. As the two materials lose their charges, the current flow will decrease.)



6. The automotive battery is a potential difference device. The battery has two distinct poles, one positive and the other negative. In a completed circuit, electrons move from the battery's electron-dense negative terminal to the battery's positive pole.

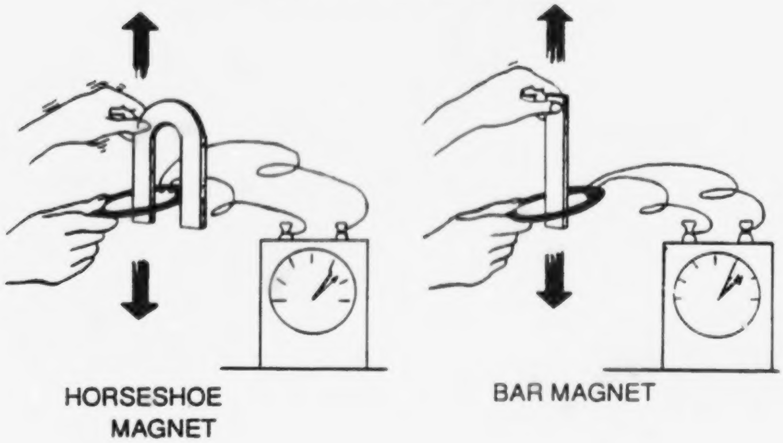


B. Magnetic fields

1. Electron flow (current flow) and magnetism are closely related. A principle of magnetic force states that, if a magnetic field passes across a conductor, electrons in that conductor will be forced to move.

   (NOTE: The strength of the magnetic field will determine the amount of force applied to the electrons.)

MAGNETISM PRODUCES ELECTRICITY



2. As a magnetic field (created by a magnet) passes across an electrical circuit, the field dislodges electrons from their orbit.

3. The free electrons are either attracted or repelled by the field, and thus current flow is created.

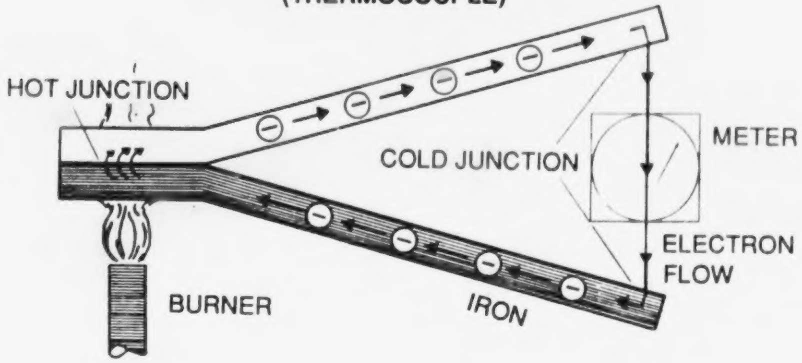
(NOTE: The stronger the magnetic field, the greater the current flow.)

C. Thermal energy

1. If two conductors, each with a slightly different electron density, are placed in a circuit and heated, electrons (current) will be forced to flow from one conductor, through the circuit, to the other conductor.

2. Electrical devices that use thermal energy to operate are sometimes called thermocouples. In automobiles thermocouples find some limited use.

HEAT PRODUCES ELECTRICITY (THERMOCOUPLE)


HOT JUNCTION
METER
COLD JUNCTION
ELECTRON FLOW
BURNER
IRON

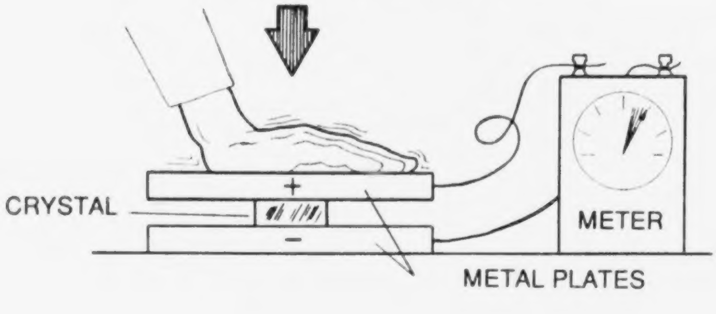
D. Crystals (piezoelectric devices)

1. If a crystal is bent or vibrated, it will produce a small amount of electrical current.

2. Though they may be used more in the future, crystals find only limited use in today's automotive electrical systems.

(NOTE: Only certain types of crystals can be used in electrical circuits. These crystals are sometimes called piezoelectric devices.)

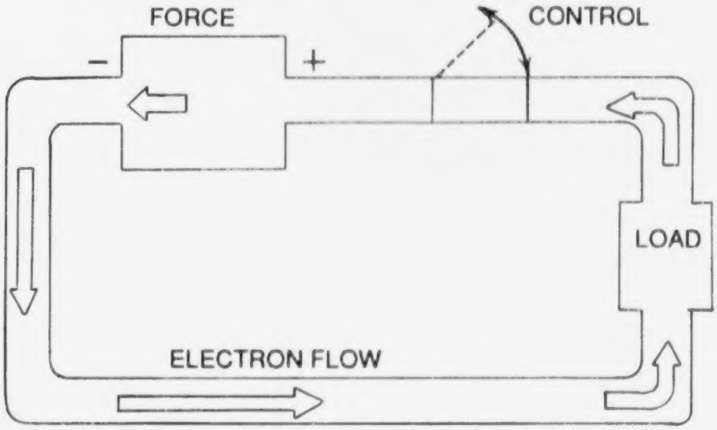
PRESSURE PRODUCES ELECTRICITY (PIEZOELECTRIC EFFECT)


+
CRYSTAL
−
METER
METAL PLATES

E. The chart below summarizes the types of electron force discussed above.

FORCE	SOURCE	RESULTS
Potential difference	difference in electron density	electron flow
Magnetic	magnetic attraction and repulsion	electron flow
Thermal	heat energy	electron flow
Crystal	deflection of crystal	electron flow

F. The illustration below shows how electron force, a load, and a control work together in a circuit.



MODULE: ELECTRICAL SYSTEMS

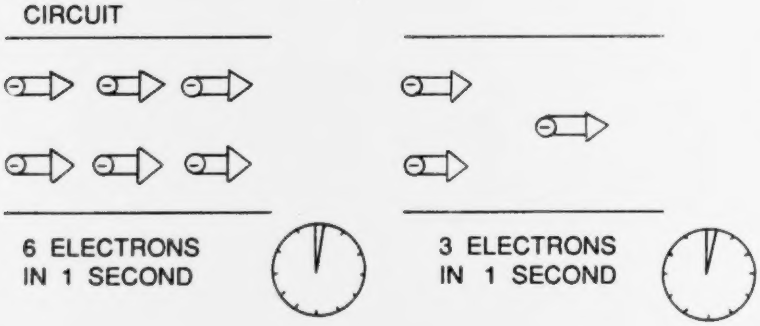
UNIT I: PRINCIPLES OF ELECTRICITY

LESSON 2: ELECTRICAL MEASUREMENT AND OHM'S LAW

I. Amperes and ohms

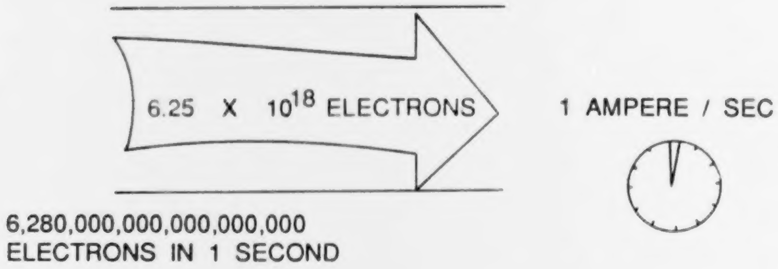
A. Amperes

1. A copper wire contains millions of atoms lined up in thousands of rows. When current flows through the wire, millions of tiny electrons are being pushed or pulled by the charge of the atoms. Knowing exactly how many electrons are moving helps a technician to know if the circuit is functioning properly.


CIRCUIT
6 ELECTRONS IN 1 SECOND
3 ELECTRONS IN 1 SECOND

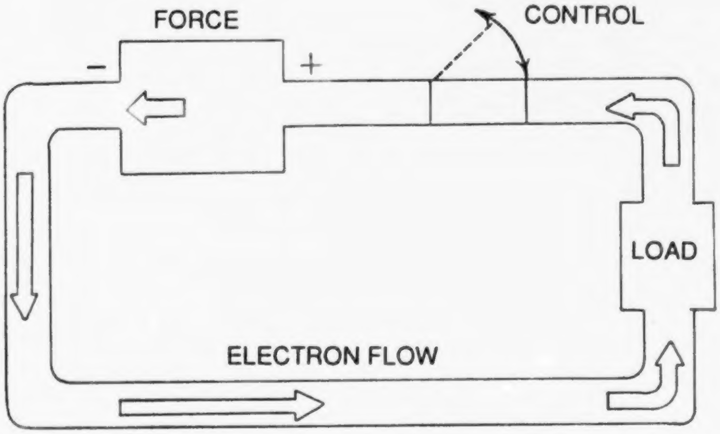
2. Andre Ampere (1775-1836) discovered that 6,280,000,000,000,000,000 electrons (6.28 X 10 {18}) pass a given point in a circuit during one second. This unit of measure has come to be known as an ampere. When 6,280,000,000,000,000,000 electrons move past a given point in the circuit in one second, one ampere-second of electrical flow has occurred.

3. As a measure of electron flow, the ampere involves both time and volume. If 12,560,000,000,000,000,000 (twice the electrons of one ampere-second) move past a given point, then two ampere-seconds of current flow have occurred. The ampere-second can be a useful diagnostic tool.


6.25 X 10^{18} ELECTRONS
1 AMPERE / SEC
6,280,000,000,000,000,000
ELECTRONS IN 1 SECOND

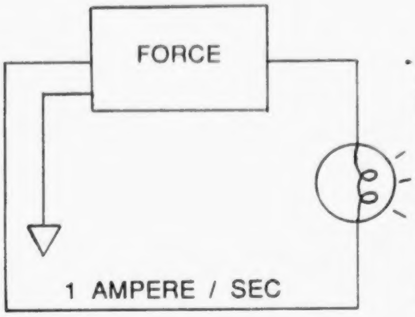
B. Ohms

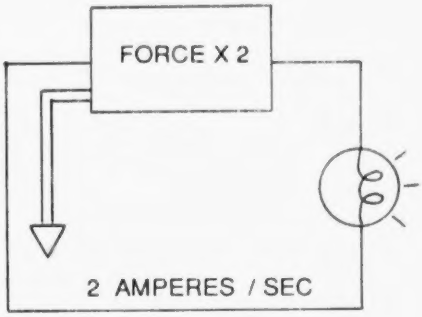
1. Current flowing in a circuit must overcome resistance. The greater a circuit's resistance, the greater the force required to maintain the electron flow. The unit of measure of resistance is the ohm.


FORCE
CONTROL
−
+
LOAD
ELECTRON FLOW

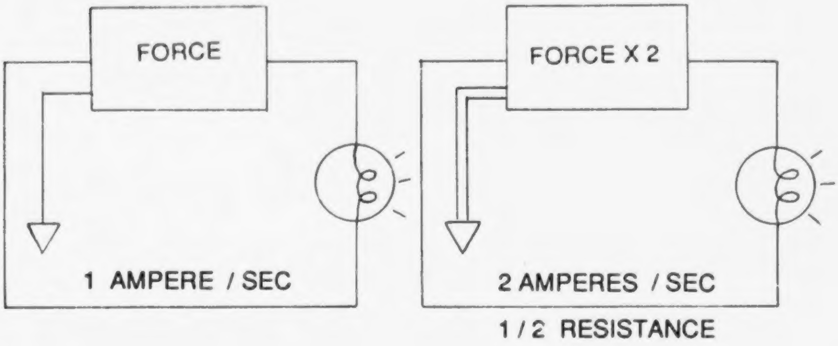
2. The volume of electrons flowing in a circuit will be determined by the amount of electron force applied against circuit resistance.

   a. Assume that a circuit and load allow one ampere-second of electron flow at a given force. If the force in the circuit is doubled, then twice as many electrons (two ampere-seconds) would be forced through the circuit.


FORCE
1 AMPERE / SEC


FORCE X 2
2 AMPERES / SEC

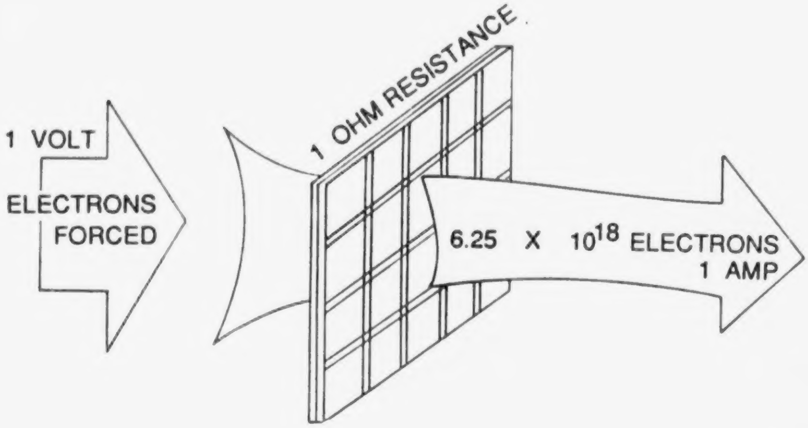
b. Inversely, assume that a bulb with half the resistance has been placed in the same circuit. The results would be the same with an equivalent force.


FORCE
1 AMPERE / SEC
FORCE X 2
2 AMPERES / SEC
1 / 2 RESISTANCE

II. Ohm's law

A. Remember that the ampere indicates the number of electrons that flow through the circuit during a given length of time.

B. The unit of measure of electron force is the volt. The volt is based upon the number of electrons that can be pushed through a circuit's resistance. One volt equals the amount of electron force required to push one ampere through one ohm of resistance.


1 VOLT
ELECTRONS FORCED
1 OHM RESISTANCE
6.25 X 10^{18} ELECTRONS
1 AMP

C. Remember that the unit of measure of electron resistance is the ohm. One ohm equals the volume of one ampere forced by one volt of electron force.

D. All three electrical units of measurement (amperes, volts, and ohms) refer in some way to the volume of electron flow. These units of measurement can be related mathematically by the following rules of electricity.

1. Volts are directly related to amperes. If volts are increased, amperes will increase. If volts are decreased, amperes will decrease.

2. Ohms are inversely related to amperes. If ohms increase, amperes will decrease. If ohms decrease, amperes will increase.

3. The above rules can be restated mathematically.

    a. Increase in volts = increase in amperes

    $>$ volts = $>$ amperes

    b. Decrease in volts = decrease in amperes

    $<$ volts = $<$ amperes

    (NOTE: This volt/ampere relationship is logical because the number of amperes produced is dependent upon the amount of force pushing them. A change in the amount of force pushing the amperes will produce a change in the rate of electron flow.)

    c. Increase in ohms = decrease in amperes

    $>$ ohms = $<$ amperes

    d. Decrease in ohms = increase in amperes

    $<$ ohms = $>$ amperes

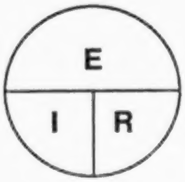
    (NOTE: The relationship between ohms and amperes is also logical. If resistance is increased, the number of electrons forced through the circuit will be reduced. If resistance is reduced a greater number of electrons will be allowed through the circuit, assuming, of course, that the amount of electron force remains constant.)

E. The relationship between ohms, amperes, and volts is called Ohm's law. Automotive technicians use Ohm's law to predict how a circuit will behave during operation. The chart below can be extremely helpful in understanding Ohm's law and should be memorized.

(NOTE: In the chart below E = volts, I = amps, R = resistance.)

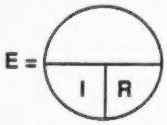
OHM'S LAW

THREE ELECTRICAL QUANTITIES IN OHM'S LAW

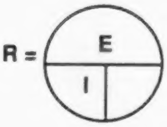


THREE FORMS OF OHM'S LAW

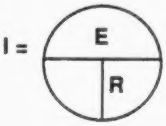
If solving for **E** cover **E** and the circle shows $E = I \times R$



If solving for **R** cover **R** and the circle shows $R = \frac{E}{I}$



If solving for **I** cover **I** and the circle shows $I = \frac{E}{R}$

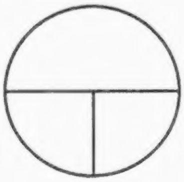


MODULE: ELECTRICAL SYSTEMS

SOLVING PROBLEMS USING OHM'S LAW

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. Write the terms "amps," "ohms," and "volts" in the proper places on the pie chart below. Use the chart to work problems that appear later in this assignment sheet.



2. Define the terms listed below.

Ampere

Ohm

Volt

3. List the three basic components of an electrical circuit.

4. List two devices that can make an electrical circuit safer and more practical.

5. A 120-volt circuit is operating a load device with a resistance of 30 ohms. Use Ohm's law to determine how many amps will flow through this circuit.

6. A circuit has 4 amps of current flow and a resistance of 3 ohms. Use Ohm's law to determine how many volts are in this circuit.

7. The resistance of a circuit has been reduced by half and the circuit's voltage has been doubled. Use Ohm's law to determine what effect these changes will have on amperage in the circuit.

8. A circuit has 12 volts applied to the current flowing through a wire with .5 (one-half) ohms of resistance. If the wire is cut in half and the ends held away from each other, how many amps would then flow through the circuit? Use Ohm's law to find the answer.

9. If an electron pump that produces 12 volts is hooked into a circuit with 120 ohms of resistance, how many amps will flow through the circuit? Use Ohm's law to find the answer.

10. If an electron pump that produces 12 volts is hooked into a circuit with 12 ohms of resistance, how many amps will flow through the circuit? Use Ohm's law to find the answer.

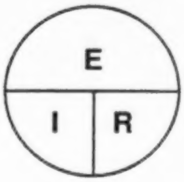
11. A 12-volt pump is going to be used in a circuit that has a load requiring 6 amps. Use Ohm's law to determine how much resistance the circuit should have before the load will work.

MODULE: ELECTRICAL SYSTEMS

SOLVING PROBLEMS USING OHM'S LAW

(ANSWER SHEET)

1.



2. An ampere is a unit of measure of current flow. One ampere (amp) equals 6.28 x 10 (18) (6,280,000,000,000,000,000) electrons passing a given point in a circuit in one second.

   An Ohm is a unit of measure of resistance in a circuit. One ohm is the amount of resistance that occurs when one volt of electricity forces one ampere through a circuit.

   A volt is a unit of measure of the force of current flow in a circuit. One volt is the amount of force needed to push one ampere of current through one ohm of resistance.

3. Current path

   Electron force

   Load

4. Control device

   Safety device

5. $\frac{120\text{ volts}}{30\text{ ohms}} = 40\text{ amps}$

6. 4 Amps x 3 Ohms = 12 volts

7. The amperage will increase.

8. Zero

9. $\frac{12\text{ volts}}{20\text{ ohms}} = 0.10\text{ amps}$

10. 12 volts

11. $\frac{\text{12 volts}}{\text{6 amps}} = \text{2 ohms}$

MODULE: ELECTRICAL SYSTEMS

UNIT I: PRINCIPLES OF ELECTRICITY

UNIT I TEST

SECTION A. Match the terms below with their appropriate definitions.

____ 1. Any device that pushes free electrons out of orbit, creating a current flow.

____ 2. The unit of measure of resistance.

____ 3. A property of a material that slows the flow of free electrons.

____ 4. Any flow of electrons in a circuit.

____ 5. Any material containing an abundance of atoms with free electrons.

____ 6. Any electrical device that requires current flow to operate.

____ 7. Anything that allows electrons to flow from and return to a source.

____ 8. The unit of measure of electron flow.

____ 9. The negatively charged parts of an atom.

____ 10. The force between two objects with the same electrical charge.

____ 11. The force between two objects with different electrical charges.

____ 12. A statement of the relationship between ohms, volts, and amps.

____ 13. The unit of measure of electrical force.

a. Ampere

b. Attraction

c. Conductor

d. Circuit

e. Current

ab. Electrical load

ad. Electrons

ae. Free electron

bc. Ohms

bd. Ohm's law

be. Repulsion

cd. Resistance

ce. Volts

SECTION B. Select the best answer from the five choices listed.

____ 14. The positively charged particles in the nucleus of an atom are called

a. protons.
b. neutrons.
c. electrons.
d. crystals.
e. molecules.

____ 15. The uncharged particles in the nucleus of an atom are the

a. protons.
b. neutrons.
c. electrons.
d. crystals.
e. molecules.

____ 16. The negatively charged particles orbiting the nucleus of an atom are the

a. protons.
b. neutrons.
c. electrons.
d. crystals.
e. molecules.

____ 17. An atom will be positively charged if it has more

a. electrons than protons.
b. electrons than neutrons.
c. protons than electrons.
d. neutrons than electrons.
e. neutrons than protons.

____ 18. An atom will be negatively charged if it has more

a. electrons than protons.
b. electrons than neutrons
c. protons than electrons.
d. neutrons than electrons.
e. neutrons than protons.

____ 19. Copper is a good conductor because it has

a. a neutral charge.
b. a positive charge.
c. a negative charge.
d. atoms which each contain an odd number of electrons.
e. atoms which each contain a free electron.

____ 20. Electrons passing from atom to atom within a circuit can be referred to as

a. crystallization.
b. reverse crystallization.
c. current.
d. negative energy.
e. magnetism.

____ 21. An electron pump is any device which

a. balances charges in atoms.
b. forces electrons to move.
c. forces neutrons to move.
d. forces protons to move.
e. does none of the above.

____ 22. In order to do work, a circuit needs a

a. protection device.
b. free proton.
c. free neutron.
d. load.
e. control device.

____ 23. Electrons which repeatedly reverse the direction of their movement in a circuit are called

a. negative electrons.
b. direct current.
c. alternating current.
d. amperes.
e. positive electrons.

____ 24. A type of electron pump that creates an excess of electrons at one end of the circuit and a lack of electrons at the other end is called a

a. regulator.
b. crystal.
c. thermocouple.
d. magnetic field.
e. potential difference device.

____ 25. A type of electron pump that can be referred to as a piezoelectric device is a

a. battery.
b. crystal.
c. thermocouple.
d. magnetic field.
e. potential difference device.

____ 26. The type of electron pump that uses heat to move electrons is called a

a. nuclear generator.
b. crystal.
c. thermocouple.
d. magnetic field.
e. potential difference device.

____ 27. An automobile battery is a type of

a. generator.
b. piezoelectric device.
c. thermocouple.
d. magnetic field.
e. potential difference device.

____ 28. One volt equals the amount of electron force required to

a. push 5 amperes through one ohm of resistance.
b. push one ampere through 5 ohms of resistance.
c. push 5 amperes through 5 ohms of resistance.
d. push 10 amperes through 10 ohms of resistance.
e. do none of the above.

____ 29. One ampere equals

a. a 10 C rise in one ounce of conductive material.
b. 6.25 volts.
c. 6.25 billion ohms.
d. 6.28 X 10 (18) electrons.
e. 500 changes in the direction of electron flow per second.

____ 30. When flowing through a circuit, electrons move

a. faster at the beginning of the circuit.
b. faster at the end of the circuit.
c. at the same speed throughout the circuit.
d. at the same speed as protons.
e. slower than protons.

____ 31. The ohm is a measure of

a. amount of time one electron needs to flow through a circuit.
b. volts.
c. resistance.
d. number of electrons flowing in a period of time.
e. 6,250,000,000,000,000 electrons.

____ 32. The volume of electrons flowing in a circuit will be determined by the

a. force/resistance.
b. amperes x ohms.
c. amperes/volts.
d. electrons/amperes.
e. ohms x resistance.

SECTION C. Read each of the below statements made by technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.

___ 33. Technician I says that increasing the voltage of a circuit will increase the amperage.

Technician II says that increasing the amperage of a circuit without increasing its resistance will not raise the voltage.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

___ 34. Technician I says that increasing the ohms of a circuit will increase the amperage.

Technician II says that increasing the ohms in a circuit without increasing the voltage will not increase the amperage.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

___ 35. Technician I says that doubling both the voltage and the resistance of a circuit will increase the amperage four times.

Technician II says that doubling both the voltage and the resistance of a circuit will not affect the amperage.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

___ 36. Technician I says that a circuit's amperage will be reduced by two thirds if its resistance is tripled and its voltage is kept the same.

Technician II says that voltage in a circuit must be increased three times in order to triple the circuit's resistance while keeping the amps the same.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

___ 37. Technician I has just added a two-ohm load in parallel to a circuit with two ohms of resistance. Technician I says that the circuit's amperage will now be cut in half.

Technician II has just added a two-ohm load in parallel to a circuit that already has a two-ohm load. Technician II says that the circuit's amperage will remain the same.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

___ 38. Technician I says that a circuit with 12 volts and a resistance of .1 (one-tenth) ohms will have 120 amps.

Technician II says that a circuit with 12 volts and a resistance of 6 ohms will have 2 amps.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

___ 39. Technician I says that if a 12-volt battery is hooked up to a circuit with only 1 ohm of resistance, there will be 12 amps flowing in the circuit.

Technician II says that a 12-volt battery is not big enough to produce 12 amps.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of _____ on the Unit I Test in order to receive an evaluation for any competencies in the Electrical Systems Module.)

ANSWERS TO UNIT I TEST

1. ab
2. bc
3. cd
4. e
5. c
6. ac
7. d
8. a
9. ad
10. be
11. b
12. bd
13. ce
14. a
15. b
16. c
17. c
18. a
19. e
20. c
21. b
22. d
23. c
24. e
25. b
26. c
27. e
28. d
29. d
30. c
31. c
32. a
33. a
34. d
35. b
36. c
37. a
38. c
39. a

MODULE: ELECTRICAL SYSTEMS

UNIT II: ELECTRICAL CIRCUIT DESIGN

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the various components of an electrical circuit and the principles by which they work. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1. I. Identify various types of conductors used in the automobile and the principles by which these conductors function (all competencies in the Electrical Systems Module, Unit II Test).

II. Identify various types of electrical insulation used in the automobile (all competencies in the Electrical Systems Module, Unit II Test).

III. Identify various types of circuit protection used in the automobile (all competencies in the Electrical Systems Module, Unit II Test).

IV. Identify various types of circuit load devices used in the automobile and the principles by which the load devices work (all competencies in the Electrical Systems Module, Unit II Test).

V. Identify various circuit-control devices used in the automobile and the principles by which the control devices work (all competencies in the Electrical Systems Module, Unit II Test).

ASE TASKS COVERED IN THIS UNIT

I. Only material that is preliminary to ASE tasks appears in this unit. No ASE tasks are covered directly.

MODULE: ELECTRICAL SYSTEMS

UNIT II: ELECTRICAL CIRCUIT DESIGN

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Information outline

    1. Lesson 1: COMPONENTS OF THE ELECTRICAL CIRCUIT

        a. Information outline

        b. Assignment sheets

            AS1-L1-UII: Circuit Components

E. Unit test

F. Answers to unit test

REFERENCES

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Chrysler Motors. 1988 Service Manual: Electrical, Fuel, and Emission Systems: Front Wheel Drive Car.

Chrysler Motors. 1988 Service Manual: Engine, Chassis, and Body: Front Wheel Drive Car.

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DeKryger, William, J., Robert T. Kovacik, and Saverio G. Bono. Auto Mechanics Theory and Service. Cincinnati: South-Western Publishing Company, 1986.

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Derato, Frank. Electrical and Electronic Systems: Shop Manual. New York: McGraw-Hill Book Company, 1986.

Downing, Ronald. Automotive Electrical Systems and Tune-up Procedures: Instructor's Guide. Module 5 of Auto Mechanics. University of Missouri-Columbia: Instructional Materials Laboratory, 1981.

Mitchell Information Services, Inc. 1986 Domestic Cars Tune up Mechanical Service and Repair. San Diego: Mitchell Information Services, Inc., 1986.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L1-UII before taking the Unit II Test.
2. The instructor should select an alternator for students doing item 2 of AS1-L1-UII.

B. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

1. Fire Safety in the Auto Shop (AM-80-110), 1980.
2. Parts Cleaning: Safe Methods of Handling and Storage (AM-80-120), 1980.
3. Auto Electrical Theory (AM-84-500), 1984.

MODULE: ELECTRICAL SYSTEMS

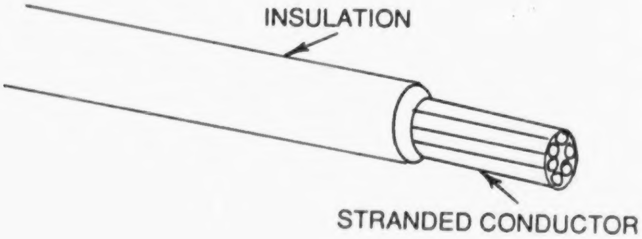
UNIT II: ELECTRICAL CIRCUIT DESIGN

LESSON 1: COMPONENTS OF THE ELECTRICAL CIRCUIT

I. Conductors

A. Stranded-wire conductor

1. Stranded wire is usually made from copper, but any conductive metal can be stranded together to form a conductor. Aluminum alloy, for example, is occasionally used as a stranded wire conductor in the automobile.



2. The stranded wire is usually covered with a polyvinyl chloride (PVC) insulation. The insulation prevents the wire from touching other conductive material.

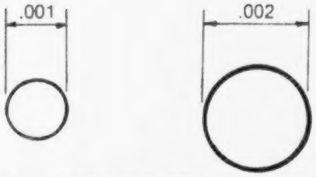
   (NOTE: A short will occur if bare electrical wire contacts another conductive material.)

3. The wires in a circuit must have enough surface area to carry the amount of current needed to operate the load properly. The wire must also be able to withstand the vibration and bending it will undergo in an automobile. Electrical current flow is measured in amperes. Stranded wire is rated according to the number of amperes that can flow through the wire without the wire becoming too hot.

4. Length also plays a role in determining wire size. The greater the distance from the source of electrical current (force), the greater the resistance to current (electron) flow. Larger sizes of wire can counter this resistance by providing a greater number of current paths to the load.

5. The American Wire Gauge System and the Metric Wire Gauge System are used to size wire. Both of these systems assign an identification number to electrical wire based upon the wire's diameter.

   a. In the American Wire Gauge System, the larger the number, the smaller the wire size. Identification numbers range from 20 gauge (a very small wire) to 000 gauge (a very large wire).



American Wire Gage Table

Gage	Dia/Mils	Circular/Mils
000 (3/0)	410	167,800
00 (2/0)	365	133,100
0	325	105,500
2	258	66,370
4	204	41,740
6	162	26,250
8	128	16,510
10	102	10,380
12	81	6,530
14	64	4,107
16	51	2,583
18	40.3	1,624
20	32	1,022
22	25.4	642

Courtesy of Delmar Publishers, A Division of Litton Educational Publishing, Inc. Albany, NY 12205
Auto Starting & Charging Systems Instructor's Guide.

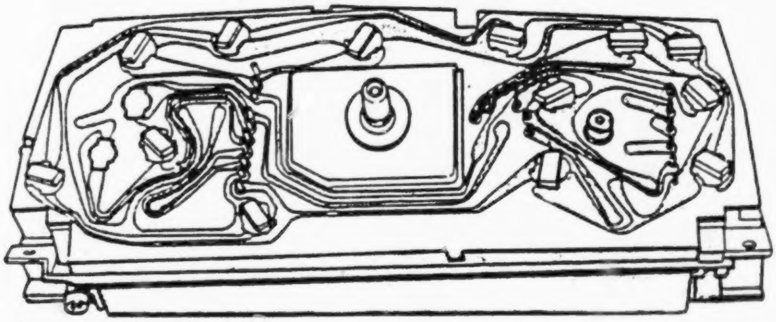
   b. The cross-section of wire is measured in a unit called a "circular mil." One circular mil is the area of a circle that is one mil in diameter.

   c. In the Metric Wire Gauge System, the larger the number, the larger the wire size. Identification numbers range from 0.5 mm (a very small wire) to 4.0 mm (a very large wire).

6. Individual electrical wires are bound into wiring harnesses and routed throughout the vehicle. To provide an orderly wiring system, the manufacturers cover the wires with different colors of insulation. The wires are identified by their colors in a wiring schematic.

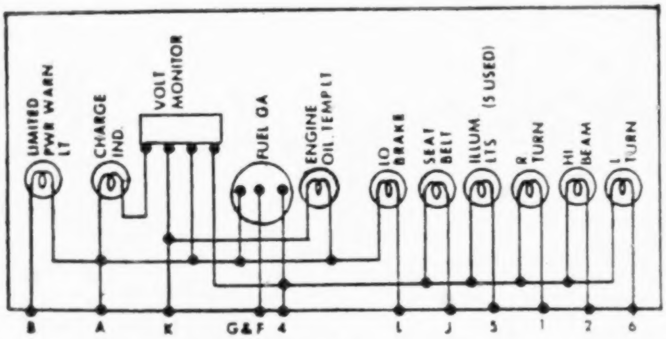
B. The printed circuit board is also a type of conductor. In the printed circuit board, copper is laminated to an insulating material made of either fiber glass, phenolic, or plastic. The copper is processed so that it forms individual strips, each of which becomes a current path for the circuits.

(NOTE: The copper strips in printed circuit boards are very thin and should be handled with care.)



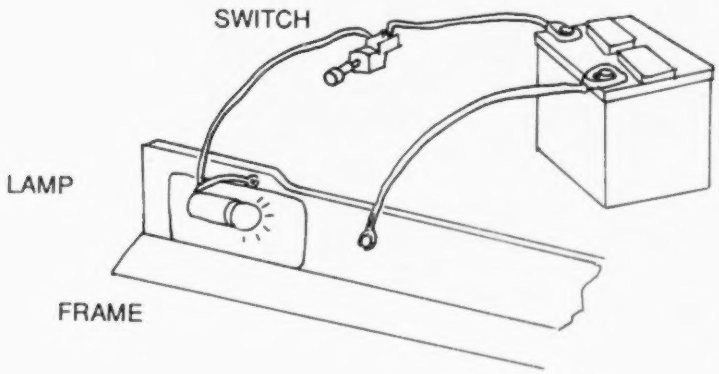
Courtesy of Chrysler Motors

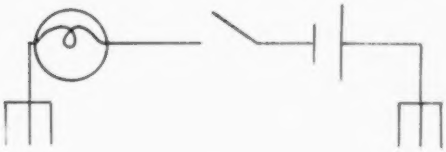
PRINTED CIRCUIT BOARD


LIMITED PWR WARN LT
CHARGE IND.
VOLT MONITOR
FUEL GA
ENGINE OIL TEMP LT
LO BRAKE
SEAT BELT
ILLUM LTS
(5 USED)
R TURN
HI BEAM
L TURN
B
A
K
G&F
4
L
J
5
1
2
6

SCHEMATIC SYMBOL FOR
PRINTED CIRCUIT BOARD

C. If the vehicle's body is constructed of metal, it can serve as a conductor. In order to cut production costs and reduce vehicle weight, automotive manufacturers have always used the steel frame and metal body of the vehicle as a current path for some circuits. Sometimes this use of the vehicle's body is called a chassis ground or a one-wire system.





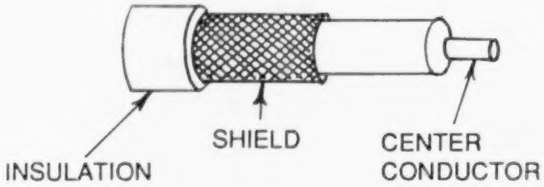
D. Spark plug wires

1. Spark plugs in early model cars were made of stranded copper, wrapped in a very thick insulation. With the introduction of car radios, a change in the construction of plug wires became necessary. The force of the electron flow was so great in spark plug wires that it would cause a popping noise in the radio. To eliminate this noise, manufacturers began to use television/radio suppression wires (TVRS) in spark plugs.

    a. The television/radio suppression wire is not really a wire at all, but instead a fiberglass cord that has been saturated with carbon, a conductive material. Heavy silicone or vinyl insulates the central cord.

    b. Carbon is not as good a conductor as copper; therefore, radio suppression wires generate less radio interference.

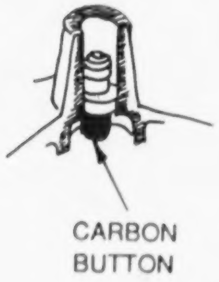
2. Special care should be exercised when removing and installing a spark plug wire. The fiberglass cord within the wire can be easily damaged if stretched. When removing spark plug boots, always use a puller.

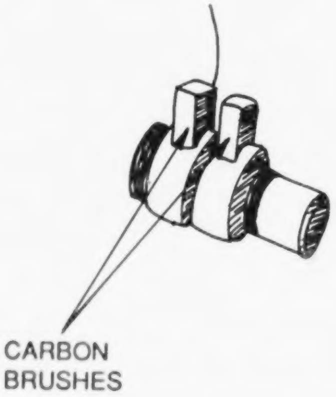


E. Carbon

1. Carbon is used in a variety of conductors. Carbon can be found in distributor caps, switches, spark plugs, alternators, and in many other electrical components. Two characteristics of carbon make it a good conductor for use in the automobile: (1) carbon has a higher resistance to current flow than other conductors; (2) carbon can rub against a moving object without losing conductivity.

2. Carbon's relatively high resistance allows for radio suppression in spark plugs and plug wires. In distributor caps and alternators, carbon rides on a rotating shaft and, thus, is rubbed against nearby moving parts. In such applications, the carbon must not only maintain current flow between the stationary and rotating parts, but also must resist the wear that can result from rubbing.



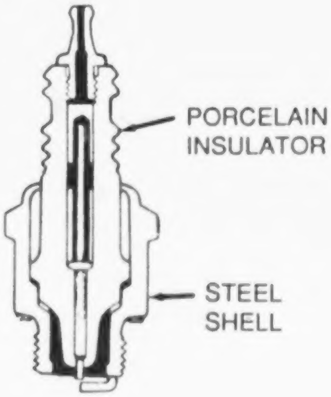


II. Electrical insulation

A. Electrical insulation serves two purposes: it keeps the electron flow inside the conductor, and prevents two different conductors from making contact.

(NOTE: As mentioned earlier, PVC is the most common type of electrical insulation. Insulation devices can be deceptive, however. Sometimes an innocent-looking flat washer can actually be an insulator keeping current in place. The technician must always know where the current is supposed to flow within the circuit that he or she is servicing.)

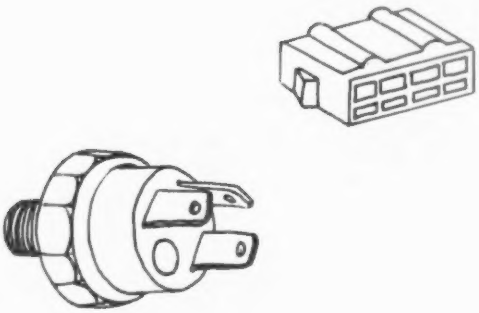
B. Glass or porcelain insulation maintains its resistance at very high temperatures and, therefore, is used in spark plugs and oxygen sensors (and in many other applications that involve high temperatures and high voltage).



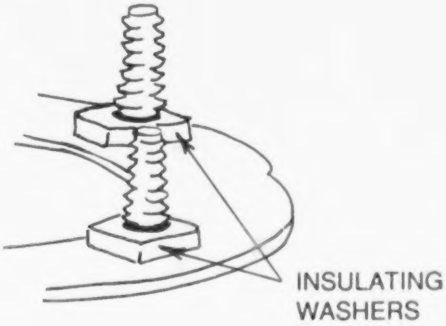
C. Bakelite, plastic, and alkyd

1. Bakelite, plastic, and alkyd are materials that are also used as rigid electrical insulation. These materials can be injection molded into almost any shape. A conductor may either be embedded into the bakelite, plastic, and alkyd or placed within these materials after they are molded.

2. The below illustration shows some examples of how rigid insulation is used in different areas of the automobile.



D. Composition or insulating washers prevent the current from grounding as it passes through other conductive materials. The below illustration shows a stud inserted through the aluminum housing of an alternator. The insulating washers keep the stud from contacting the housing.



E. Conductors that lie very close to each other are often coated with varnish. The varnish ensures that current does not leak from one conductor to the other. Any wrapped coil will be coated with varnish.

III. Circuit protection devices (fuses, fusible links, and circuit breakers)

(NOTE: Fuses, fusible links, and circuit breakers are all designed to open the electrical circuit when excess current flows through it.)

A. The fuse

1. A fuse is a strip of zinc bonded between two endcaps. The zinc strip is encased in either a glass, plastic, or ceramic sleeve. The zinc strip will destruct at a specific amperes of current flow.

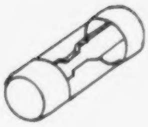
2. Fuses are categorized by a letter system and a number. The number indicates the maximum current-carrying capacity of the fuse. For example, the number and letters SFE-14 denote a 14-amp fuse.

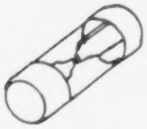
3. The appearance of a blown fuse can indicate why the circuit overloaded.

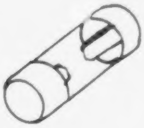
a. Small breaks in the zinc indicate a high-voltage surge or a momentary or slight current overload.

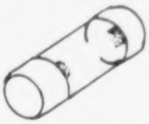
b. Large breaks indicate a high-current overload (grounded conductor) or a loss of circuit resistance (shorted load).

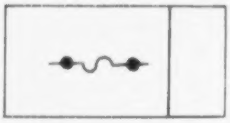
c. Vaporized breaks indicate a grounded circuit.


NORMAL


SMALL BREAK


LARGE BREAK


VAPORIZED


FUSE

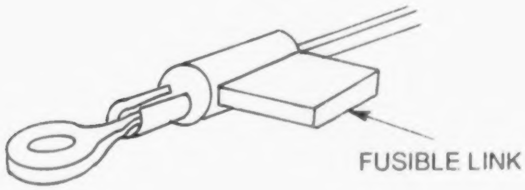
B. The fusible link

1. The fusible link is a short piece of wire that has been alloyed. The alloy causes the fusible link to destruct at a specific amperes of current flow.

2. Fusible links are rated by wire gauge size and amperes.

3. Fusible links are usually located near the terminal connection to the power source (force device). Fusible links sometimes have a molded flag at the terminal end. The flag indicates the ampere rating or gauge size of the link.

4. Locating a blown link is sometimes difficult. Insulation surrounding a destroyed fusible link will often appear undamaged (though the insulation may be somewhat soft). The break in the link can usually be located by squeezing or pulling gently on the wire.



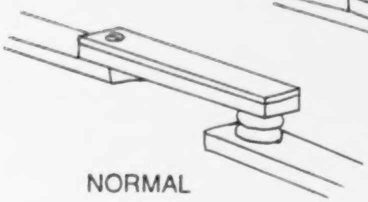
(NOTE: Never bypass a blown link to restore a circuit. Always replace the fusible link with the correct gauge and appropriate length of fusible link wire.)

C. The circuit breaker

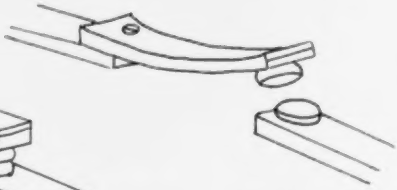
1. The circuit breaker is a thermally operated device. A bimetallic strip keeps contact points on the breaker closed. When current flow through the strip becomes too great, the strip overheats and bends, thus opening the contact points and disrupting operation of the circuit. When the strip cools, it contracts and closes the contacts, thus reactivating the circuit.

2. If the circuit overload persists, the circuit breaker will again overheat and open, causing the circuit to come off and on intermittently.

(NOTE: Continuous circuit breaker action can result in premature failure of the breaker. The technician should always eliminate the overload as soon as possible.)



NORMAL



OVERLOAD

CIRCUIT BREAKER

3. Circuit breakers are rated according to their maximum current draw before opening.

IV. Circuit load devices

A. To qualify as a load device, an electrical component must meet the three requirements listed below.

1. The load device must have some current resistance. Current resistance ensures that the force device is not depleted too rapidly and that the rate of current flow exceeds the carrying capacity of the conductors within the circuit.

2. The resistance of a load device must never be great enough to prevent current flow within the circuit. A load device with too much resistance would not use any current and, therefore, would not truly be a load.

3. The load must perform some observable function, such as producing light, heat, or magnetism.

B. Illumination loads

1. Incandescent bulbs are the most common source of light in the automobile today. Incandescent lights are essentially electric heaters.

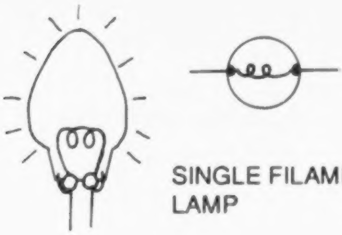
2. Incandescent bulbs fall into two general categories: single filament and multiple filament.

a. Single-filament incandescent bulbs usually have a single insulated contact. The bulbs are grounded through their sockets. In some smaller single-filament bulbs, a separate contact provides ground.

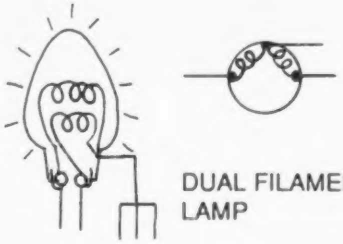
b. Multiple-filament incandescent bulbs usually have two heating filaments. They may be grounded either by a socket or by a separate terminal or contact.

3. A numbering system is used to categorize incandescent bulbs according to their use.

4. The lower the resistance of a filament, the greater the current flow through it and the brighter the light produced.



SINGLE FILAMENT LAMP

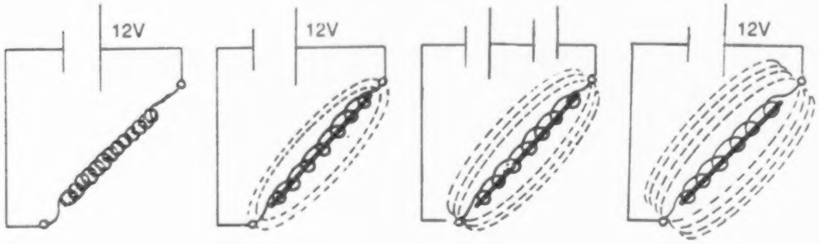


DUAL FILAMENT LAMP

C. Coil-wrapped loads (or wound coils) are used in a multitude of electrical load devices such as starters, relays, ignition coils, wiper motors, gauges, and alternators. Wound coils function according to the three basic magnetic principles listed below.

1. If a current is being forced through a conductor, a magnetic field will be created around that conductor.

2. To increase the strength of the magnetic field, the conductor can be wrapped into a coil. Increasing current flow through the conductor or placing an iron core within the coil will also increase the strength of the magnetic field.



3. A wrapped conductor that produces a magnetic field (when current passes through it) is a load device.

D. Thermal loads

1. The maximum current-carrying capacity of some special conductors is balanced with the amount of heat that the conductor can safely handle. As current flows in the circuit, the conductor will produce heat. Conductors that function in this way are called thermal loads.

(NOTE: Nichrome is the most common type of thermal load conductor. Nichrome can produce intense heat from large amounts of current flow without sustaining damage.)

2. The heat produced by thermal loads can perform a variety of functions in the automobile, such as defrosting windows, operating warning gauges, and warming carburetor choke housings.

E. Capacitor loads

1. A capacitor (condenser) is a load device that can store electrons.

2. When current is flowing in one direction, the capacitor will collect and store electrons until it is completely saturated (full). When the current is reversed, the capacitor will release the stored electrons until none remain or until the current is again reversed.

3. While the capacitor is collecting electrons (charging), it is functioning as a load device. When the capacitor is delivering electrons (discharging), it is functioning as a force device.

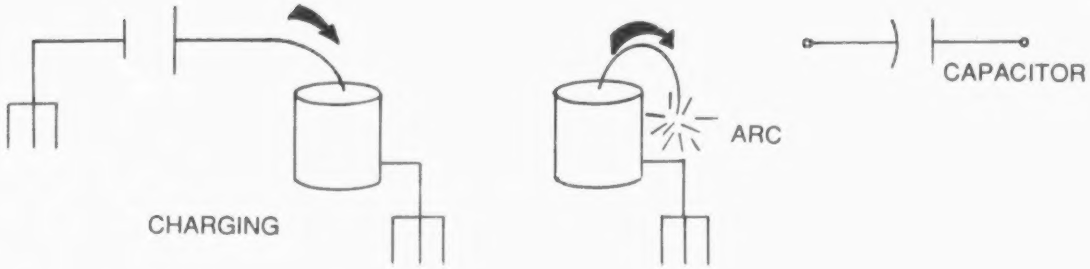
4. This ability to charge and discharge allows the capacitor to perform many useful functions in the automobile, some of which are listed below.

   a. Capacitors absorb transient current from the ignition and charging systems and are, therefore, useful in radio frequency suppression systems.

   b. Capacitors absorb excessive coil energy after spark plug firing.

   c. Capacitors protect sensitive electronic circuits in automotive computers.

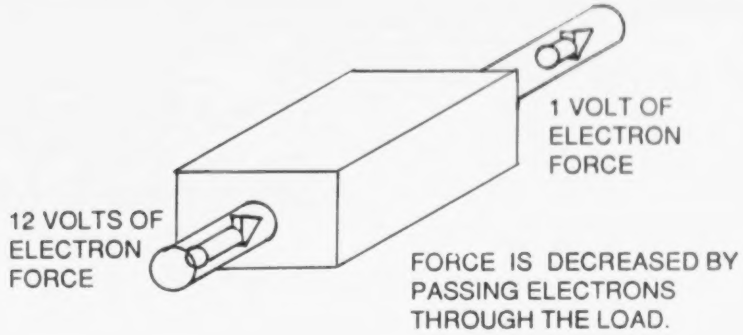
   d. Capacitors can multiply primary coil current for increased ignition coil output (capacitor discharge ignition).



F. Resistor loads

1. A resistor is either a mechanical or semiconductor device, which reduces the electrical force in a circuit. All loads reduce electrical force to some degree.

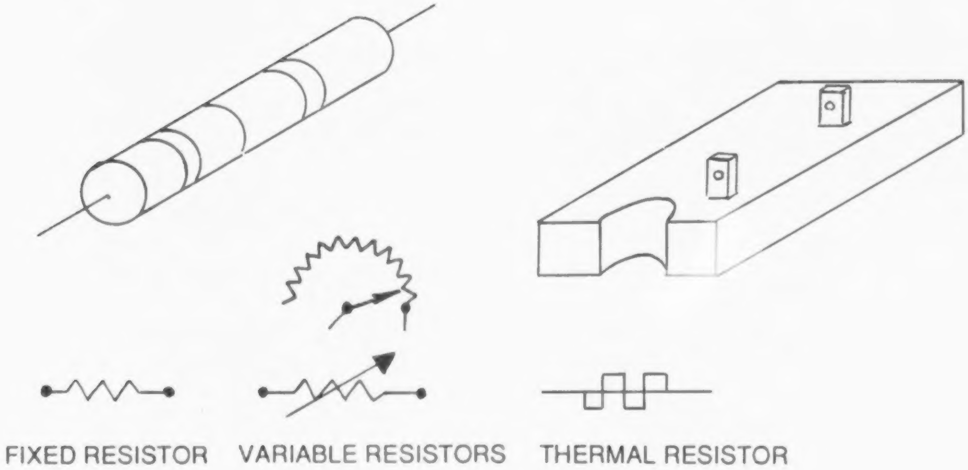
2. The force reduction across a load is called a voltage drop. When electrons are forced through a coil, light bulb, or heater, they are converted into magnetism, heat, light, or motion.


1 VOLT OF
ELECTRON
FORCE
12 VOLTS OF
ELECTRON
FORCE
FORCE IS DECREASED BY
PASSING ELECTRONS
THROUGH THE LOAD.

3. Like any load device, a resistor will cause a voltage drop to occur across itself. A resistor differs from other load devices in that its single purpose is to produce a voltage drop, causing the circuit to operate at a lower voltage.

   a. The heat and magnetism produced by the resistor have no practical use.

   b. Resistors fall into three basic classifications: fixed (carbon) resistors; thermal (temperature sensitive) resistors; and variable (adjustable) resistors.

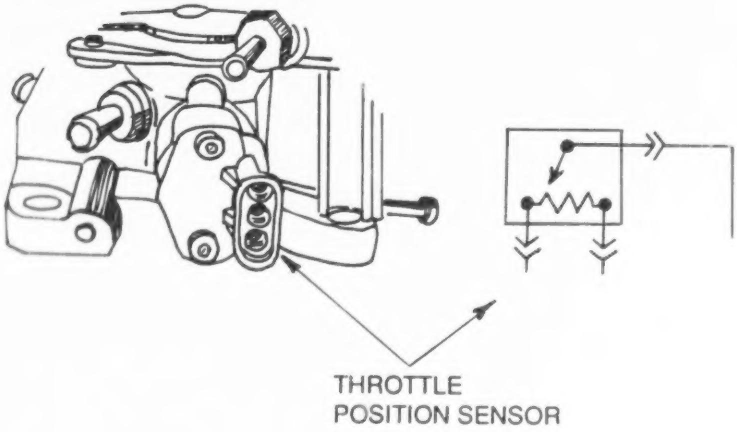

FIXED RESISTOR
VARIABLE RESISTORS
THERMAL RESISTOR

G. Variable-control devices

1. Variable-control devices and resistor load devices are similar because both create a voltage drop across the circuit. The voltage drop can control the rate of current flow through another component of the circuit. This other component then becomes dependent upon the variable-control device for current.

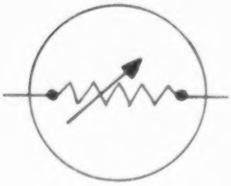
2. There are two classes of variable-control devices: mechanical and electronic.

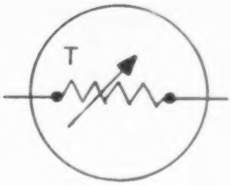
    a. Mechanical variable-control devices are usually potentiometers, a kind of variable resistor. Mechanical variable-control devices usually consist of a length of resistance wire wound around an insulator. A wiper arm slides along the windings and increases or decreases the resistance.



    b. Electronic variable-control devices are categorized as current sensitive or temperature sensitive. Current-sensitive variable-control devices vary their resistance according to the rate of current flowing through them. Temperature-sensitive variable control devices vary their resistance according to the temperature around them.

    (NOTE: There are two types of temperature-sensitive resistors: thermal resistors, which increase resistance as temperature increases; and thermistors, which decrease resistance as temperature increases.)





V. Circuit control devices

A. In order for a circuit to be functional, the amount of current flowing through it must be controlled. Current must also be made to flow at the proper time. Circuit control devices provide this control. A control device must perform one of the following tasks.

1. Opening or closing the circuit by mechanical or electronic means

2. Relaying large current rate by means of a small current signal

3. Increasing or decreasing current rate

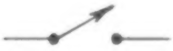
B. Contact switches

1. Switches are categorized according to the following two characteristics: the number of current paths (poles) into and out of the switch (throws); and the current-carrying capacity of the contacts inside the switch.

a. A single input (pole) single output (throw) switch would be called a single pole single throw switch (SPST).

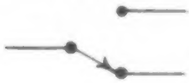
b. A single input (pole) double output (throw) switch would be called a single pole double throw (SPDT) switch.

SINGLE POLE
SINGLE THROW



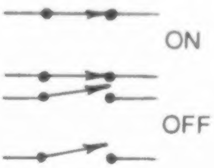
SPST

TWO POLE
SINGLE THROW



DPST

DOUBLE POLE
DOUBLE THROW



DPDT

2. Switches can be push-pull, rotary, or momentary on/off.

C. Relay controls

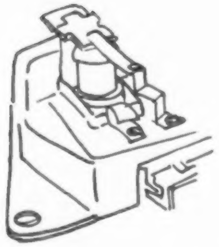
1. The primary purpose of a relay is to allow large amounts of current to be controlled by a small amounts of current.

2. There are two types of relay circuit control: the mechanical relay and the electronic control unit.

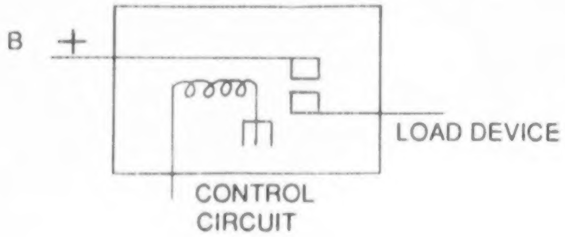
3. A mechanical relay consists of a coil load device that creates a magnetic field when energized.

   a. The magnetic field pulls upon a moveable swing arm with a contact point.

   b. When the field is strong enough to close the contact, high current flows through the contacts to a load device in the circuit.



RELAY

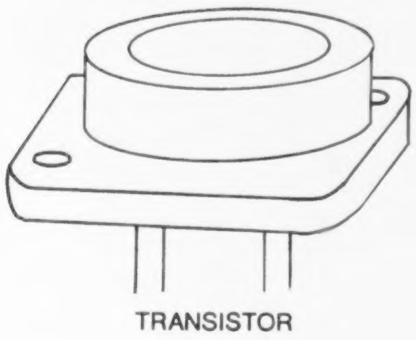


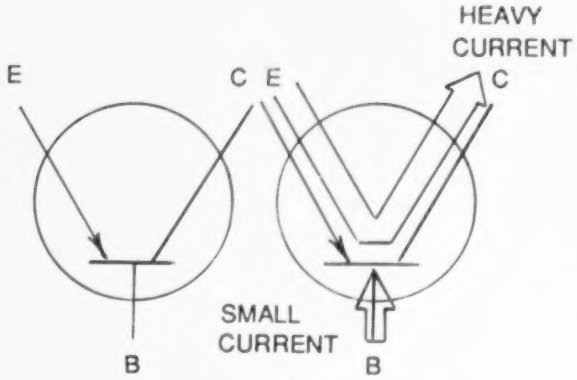
   c. The mechanical relay may have more than one set of contacts that are controlled by a single coil.

D. Electronic relay controls

1. The electronic relay has the same function as the mechanical relay. The transistor and silicon-controlled rectifier (SCR) are two examples of electronic relay controls that are currently used in automotive electronic control systems.

2. The transistor is a solid-state device, which is usually at the heart of an elaborate electronic circuit. In the transistor (as in the mechanical relay) heavy current flow is controlled by a small current.

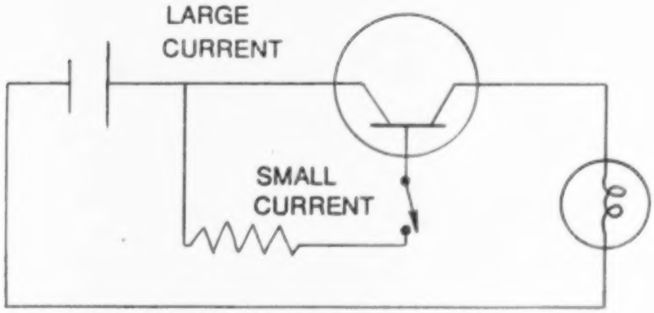




3. The transistor functions as a control relay device in most automotive electronic circuits. It has replaced ignition contact points, voltage regulator relays, and turn signal flashers.

   a. A major advantage of a transistor is that it contains no moving parts, which are subject to wear.

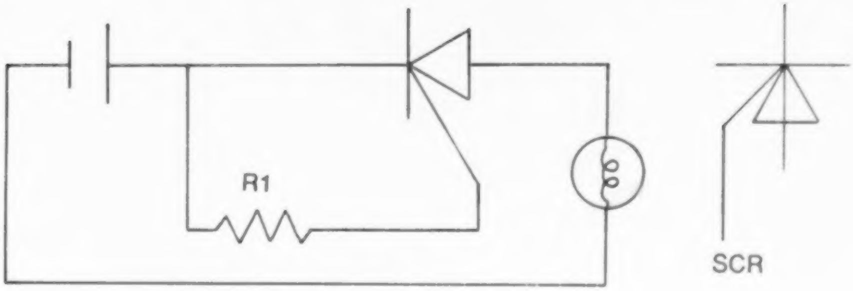
   b. The transistor is very sensitive to over current and, therefore, must be surrounded by a protective electronic circuit.



THE SWITCH CONTROLS THE HEAVY CURRENT FLOW.

   c. The transistor is also very sensitive to heat and is usually installed as a metal or aluminum heat sink.

4. Like the transistor, the SCR will control a heavy current path with a small current control. The SCR, however, is used at points where the current is too heavy for transistors.

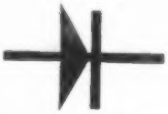


E. The diode

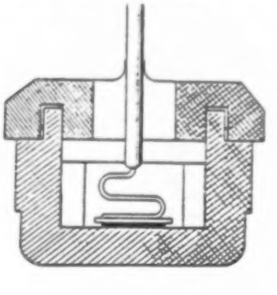
1. The diode is a device that controls the direction of current flow but not the rate of flow. The diode acts as a one-way electron check valve, allowing current to flow in one direction but blocking flow coming from the other direction.

2. One use of the diode is to convert AC current to DC current in the automobile's alternator.

DIODE



DIODE CROSS SECTION

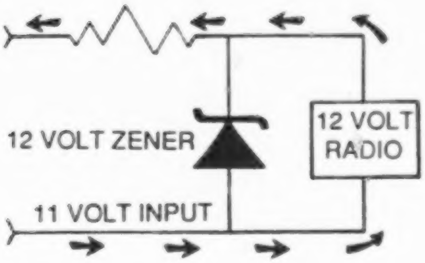


F. The zener diode

1. The zener diode is similar to a standard diode. Under normal conditions, the zener diode allows current flow in one direction, while stopping current flow in the opposite direction up to a point. If, however, the opposing current flow is forced hard enough, the zener diode will break down, allowing the current to flow in either direction.

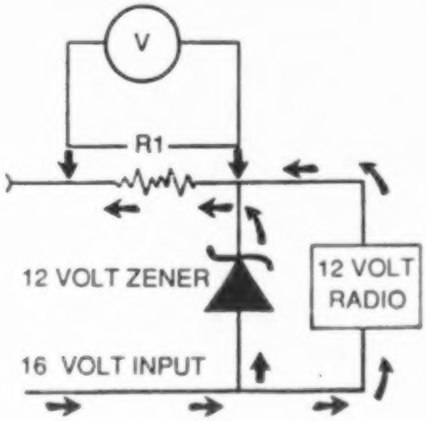
2. When the opposing voltage (electron force) decreases, the zener will again function as a standard diode.

ZENER VOLTAGE REGULATOR


12 VOLT ZENER
12 VOLT RADIO
11 VOLT INPUT

1. WITH LESS THAN 12 VOLTS APPLIED, ZENER DIODE DOES NOT CONDUCT. RADIO GETS ALL CURRENT.

2. WITH MORE THAN 12 VOLTS APPLIED, ZENER IS IN PARALLEL WITH RADIO, THE TOTAL CIRCUIT CURRENT IS INCREASED.


V
R1
12 VOLT ZENER
12 VOLT RADIO
16 VOLT INPUT

3. INCREASED CURRENT DUE TO ZENER CURRENT CAUSES EXCESS VOLTAGE TO BE DROPPED ACROSS R1.

AS1-L1-UII

MODULE: ELECTRICAL SYSTEMS

CIRCUIT COMPONENTS

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. List two reasons why automobile manufacturers use the frame and body of a vehicle as a conductor.

2. Using a service manual, determine the American or metric wire gauge of the power wire on an alternator selected by the instructor.

3. List three functions that a capacitor performs in an electrical circuit.

4. Explain the advantage of using fiberglass cords saturated with carbon as spark plug wires.

5. What information is contained in the number stamped upon a fuse?

6. What is indicated by a break in the zinc strip of a fuse?

7. Explain how to check if a fusible link has blown.

8. Make a list of the circuits in a vehicle that use either a thermal or variable resistor. Indicate the type of resistor that is used in each case.

	Circuit	Type of resistor
a.		
b.		
c.		
d.		
e.		
f.		

9. Make a list of the circuits in a vehicle that use a relay. Using a service manual or component locator, determine the location of the relay in the vehicle.

	Circuit	Location
a.		
b.		
c.		
d.		
e.		
f.		

10. Both thermal resistors and thermistors cause a voltage drop. Explain how these two devices are different.

MODULE: ELECTRICAL SYSTEMS

CIRCUIT COMPONENTS

(ANSWER SHEET)

1. Using the frame and body as a conductor cuts production costs and reduces vehicle weight.

2. (Responses will vary. The instructor should determine what is acceptable.)

3. The capacitor does all of the following: absorbs transient current; absorbs radio interference; protects sensitive electronic circuits; absorbs excessive coil energy after spark plug firing; controls primary current flow in capacitor discharge systems.

   (NOTE: Any three of the above answers would be an adequate response to item 3.)

4. Fiberglass cords saturated with carbon allow for radio suppression.

5. The number indicates the maximum current-carrying capacity of the fuse.

6. A break in the zinc strip of a fuse indicates high current overload within the circuit.

7. Squeeze or pull gently on the wire in the link to determine if there is a soft spot in the insulation. A soft spot indicates that the link is blown.

8. (Responses will vary. The instructor should determine what is acceptable.)

9. (Responses will vary. The instructor should determine what is acceptable.)

10. The thermal resistor causes the voltage drop to increase as the temperature of the resistor increases. The thermistor causes the voltage drop to decrease as the temperature of the thermistor increases.

MODULE: ELECTRICAL SYSTEMS

UNIT II: PRINCIPLES OF ELECTRICITY

UNIT II TEST

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 1. The stranded wire conductor is usually made from carbon.

____ 2. The greater the distance from the source of power, the greater the resistance a conductor will have.

____ 3. The American Wire Gauge System uses letters of the alphabet to indicate wire size.

____ 4. In the early days of automobile production, manufacturers sometimes used the steel in the car body as a current path. Manufacturers abandoned this practice when better conductors became available.

____ 5. Television/radio suppression wires are really not wires at all, but rather a glass fiber cord that has been saturated by heavy carbon.

____ 6. Carbon is not as good a conductor as copper.

____ 7. Porcelain cannot be used as electrical insulation in high-temperature applications because it may crack or melt.

____ 8. Polyvinyl chloride (PVC) or vinyl insulation is the most common type of insulation.

____ 9. Materials such as bakelite, plastic, and alkyd can be injection molded into an almost limitless number of specifically shaped insulators.

____ 10. Composition or insulation washers isolate the current path from the ground as it passes through other conductive materials.

____ 11. Carbon is highly valued as a conductor because of its relatively high resistance and its ability to rub against a moving object without losing conductivity.

____ 12. Carbon can only be used in distributor caps and spark plugs.

____ 13. The carbon in printed circuit boards forms individual strips, each of which becomes a current path.

____ 14. Unlike spark plug wires in early model cars, modern spark plug wires are made of stranded copper, wrapped in a very thick insulation to prevent current from leaking to ground.

____ 15. The three basic types of circuit protection are the fuse, the fusible link, and the circuit breaker.

____ 16. While the zener diode primarily allows current flow in only one direction, it will allow current to flow in the opposite direction if the opposing current flow is forced hard enough.

____ 17. Mechanical variable-control devices usually consist of a length of resistance wire wound around a copper wire.

____ 18. Electronic variable control devices are categorized as current or temperature sensitive.

SECTION B. **Match the terms below with their appropriate definitions.**

____ 19. A device which keeps the electron flow inside the conductor.

____ 20. A device made of strips of zinc bonded between two endcaps encased in a glass or ceramic sleeve.

____ 21. A load that is essentially an electric heater.

____ 22. A device that relays a large current rate by means of a small current signal.

____ 23. An electrical load device used for electrical system activities that call for the storage of electrons.

____ 24. A mechanical or semiconductor device that reduces the electrical force in a circuit.

____ 25. A device that is an example of an electronic relay control.

____ 26. A short piece of alloyed wire that is designed to destruct at a specific amperes of current flow.

____ 27. Material that can be used for rigid electrical insulation.

____ 28. A conductive material that can withstand movement and rubbing.

a. Bakelite
b. Resistor
c. Circuit control device
d. Fusible link
e. Incandescent light
ab. Capacitor
ac. Fuse
ad. Carbon
ae. Transistor
bc. Electrical insulation
bd. Circuit breaker

SECTION C. **Select the best answer from the five choices listed.**

____ 29. A fuse is categorized by a letter and number system. The number indicates the

a. physical size of the fuse.
b. type of vehicle in which the fuse can be used.
c. material of which the fuse is made.
d. current-carrying capacity of the fuse.
e. minimum number of hours that the fuse can be expected to function.

____ 30. Current flowing through a load can produce

a. light.
b. magnetism.
c. heat.
d. voltage drop.
e. all of the above.

____ 31. The number of heating filaments used in most multiple- filament bulbs is

a. two.
b. four.
c. five.
d. six.
e. nine.

____ 32. The wound coil is used in

a. gauges.
b. starters.
c. wiper motors.
d. alternators.
e. in all the above load devices as well as in many others.

____ 33. The most common type of conductor used in a thermal load is

a. bakelite.
b. carbon.
c. copper.
d. nichrome.
e. alkyd.

____ 34. A capacitor is used in electrical system activities that call for

a. use of DC current only.
b. storage of electrons.
c. frequent voltage drops.
d. creation of intense heat.
e. creation of a strong magnetic field.

____ 35. The ability of a capacitor to charge or discharge allows it to perform such functions as

a. greatly strengthening magnetic fields at various points within the circuit.
b. producing heat that can be used to defrost windows and operate choke housings.
c. protecting sensitive electronic circuits in automotive computers.
d. reducing primary coil current for more consistent ignition coil output.
e. boosting the energy of the coil after spark plug firing.

____ 36. The heat, magnetism, and light produced by the capacitor

a. can be used in the vehicle's heating system.
b. have no practical use.
c. can be used to operate warning gauges in some vehicles.
d. had some limited use in early vehicles.
e. aid the function of automotive computers.

____ 37. To qualify as a circuit control device, a component must

a. open or close the circuit either mechanically or electronically.
b. relay large current rate by means of a small current signal.
c. variably increase or decrease current rate.
d. perform any one of the above functions.
e. perform none of the above functions.

____ 38. Contact switches are categorized by the current-carrying capacity of the contacts inside the switch and the

a. number of current paths (poles) into and out of the switch.
b. number of current paths into the switch only.
c. the number of current paths out of the switch only.
d. the complexity of the circuit for which the switch will be used.
e. the material of which the switch is made.

____ 39. The primary purpose of a relay is to

a. allow a small current rate to be controlled by a larger control current rate.
b. allow a large current rate to be controlled by a smaller control current rate.
c. ensure that powerful magnetic fields do not interrupt the operation of neighboring components in the circuit.
d. ensure that magnetic fields produced by other components are powerful enough to maintain the smooth operation of those components.
e. allow circuits to be switched on and off from a variety of positions in the circuit.

____ 40. The transistor is used as a control relay device in

a. the horn circuit.
b. turn signal flashers only.
c. components which produce a good deal of overcurrent.
d. ignition contact points only.
e. most automotive electronic devices.

____ 41. The silicon-controlled rectifier (SCR) is similar to the transistor but is used primarily when

a. current flow is too light for transistors.
b. a circuit is subject to frequent voltage drops.
c. printed circuit boards are not present in a vehicle.
d. AC current must be rectified to DC current.
e. current is too heavy for transistors.

____ 42. The diode is a circuit control device that controls

a. the direction of current and its rate of flow.
b. the direction of current but not its rate of flow.
c. the current's rate of flow but not its direction.
d. neither the direction of current nor its rate of flow.
e. circuit flow in the same manner as a transistor.

____ 43. Variable control devices are similar to resistor load devices because both

a. create voltage drops across the circuit.
b. guard against voltage drops across the circuit.
c. have the ability to absorb great amounts of heat.
d. are classified as a type of thermistor.
e. make extensive use of carbon.

SECTION D. **Read each of the below statements made by technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.**

____ 44. Technician I says that varnish is sometimes used to reduce the resistance of a conductor.

Technician II says that a bakelite washer can be used as an insulator in some electrical circuits.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 45. Technician I says that, when removing spark plug boots, a puller should be used.

Technician II says that glass fiber is used to make spark plug wires more durable.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 46. Technician I says that small breaks in a fuse indicate it probably was blown as a result of a high-voltage surge.

Technician II says that large breaks in a fuse indicate it probably was blown as a result of a grounded circuit.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 47. Technician I says that the numbers and letters SFE-14 indicate that a fuse has a 14-amp rating.

Technician II says that vaporized breaks in a fuse indicate that it probably was blown as a result of a high-current overload.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 48. Technician I says that, unlike fuses, a fusible link can often be repaired and used again.

Technician II says that insulation around a blown fusible link will remain undisturbed even though the wire itself will destruct.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 49. Technician I says that a blown fusible link should be bypassed to restore the circuit if the circuit will be operated for only a short amount of time.

Technician II says that a blown fuse should never be bypassed in order to restore a circuit.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 50. Technician I says that consistent circuit breaker action will cause premature failure of the breaker.

Technician II says that circuit breakers are expendable.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of _____ on the Unit II Test in order to receive an evaluation for any competencies in the Electrical Systems Module.)

ANSWERS TO UNIT II TEST

1. f
2. t
3. f
4. f
5. t
6. t
7. f
8. t
9. t
10. t
11. t
12. t
13. t
14. f
15. t
16. t
17. f
18. t
19. bc
20. ac
21. e
22. c
23. ab
24. b
25. ae
26. d
27. a
28. ad
29. d
30. e
31. a
32. e
33. d
34. b
35. c
36. b
37. d
38. a
39. b
40. e
41. e
42. b
43. a
44. b
45. a
46. c
47. a
48. b
49. b
50. c

MODULE: ELECTRICAL SYSTEMS

UNIT III: TESTING AND DIAGNOSING ELECTRICAL CIRCUITS

UNIT OBJECTIVE

After completing this unit, the student should be able to identify typical electrical circuit malfunctions and the procedures by which they can be diagnosed. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify three types of circuit arrangements and the principles by which they function (Competencies D1-D5, Part I of Unit III Test).

II. Identify the typical functions of the three types of electrical circuit arrangements used in the automobile (Competencies D1-D5, Part I of Unit III Test).

Lesson 2. I. Identify the equipment used to test electrical circuits and the principles by which the equipment functions (Competencies D1-D5, Part I of Unit III Test).

II. Identify the various procedures for testing electrical circuits (Competencies D1-D5, Parts I and II of Unit III Test).

III. Identify the various types of fault-testing procedures and the situations in which they should be used. (Competencies D1-D5, Part II of Unit III Test).

Lesson 3. I. Identify the various safety procedures used in testing and repairing electrical circuits (Competencies D1-D5, Part I of Unit III Test).

II. Demonstrate the ability to:

a. Measure voltage in a circuit (Competency D4, JS1-L3-UIII).

b. Measure resistance in a circuit (Competency D3, JS2-L3-UIII).

c. Measure current in a circuit (Competency D5, JS3-L3-UIII).

d. Determine voltage and continuity of a circuit using a test light (Competency D1, JS4-L3-UIII).

e. Fault test a circuit (Competency D2, JS5-L3-UIII).

f. Check continuity in automotive electrical circuits (Competency D1, JS6-L3-UIII).

g. Check for opens, shorts, and grounds (Competency D2, JS7-L3-UIII).

h. Measure resistance in a circuit (Competency D3, JS8-L3-UIII).

i. Measure volts in a circuit (Competency D4, JS9-L3-UIII).

j. Measure current in a circuit (Competency D5, JS10-L3-UIII).

k. Check electrical circuit safety devices (Competencies D1-D3, JS11-L3-UIII).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks F001-F005. The job sheets can be adapted to cover ASE tasks F006 and F007.

MODULE: ELECTRICAL SYSTEMS

UNIT III: TESTING AND DIAGNOSING ELECTRICAL CIRCUITS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Information outline

  1. Lesson 1: CIRCUIT ARRANGEMENTS AND THEIR VARIOUS USES

    a. Information outline

  2. Lesson 2: TEST EQUIPMENT AND TEST PROCEDURES

    a. Information outline

  3. Lesson 3: SAFETY IN TESTING ELECTRICAL SYSTEMS

    a. Information outline

    b. Job sheets

JS1-L3-UIII:	Measuring Voltage in a Circuit
JS2-L3-UIII:	Measuring Resistance in a Circuit
JS3-L3-UIII:	Measuring Current in a Circuit
JS4-L3-UIII:	Determining Circuit Voltage and Continuity Using a Test Light
JS5-L3-UIII:	Fault Testing Procedure
JS6-L3-UIII:	Checking Continuity in Automotive Electrical Circuits
JS7-L3-UIII:	Checking For Opens, Shorts, and Grounds in an Automotive Electrical Circuit
JS8-L3-UIII:	Measuring Resistance in an Automotive Electrical Circuit
JS9-L3-UIII:	Measuring Volts in an Automotive Electrical Circuit
JS10-L3-UIII:	Measuring Current in an Automotive Electrical Circuit
JS11-L3-UIII:	Inspecting, Testing, and Replacing Fusible Links, Circuit Breakers, and Fuses in an Automotive Electrical Circuit

E. Unit test

F. Answers to unit test

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Mitchell Information Services, Inc. 1986 Domestic Cars Tune up Mechanical Service and Repair. San Diego: Mitchell Information Services, Inc., 1986.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. The activities in JS1-L3-UIII through JS5-L3-UIII are bench work. Students should do bench work before working on electrical circuits in a vehicle.
2. Create an open in a circuit for students doing item 2 of JS5-L3-UIII.
3. Provide a fault in a circuit for students doing item 2 of JS6-L3-UIII.
4. Provide a fault in a circuit for students doing item 3 of JS6-L3-UIII.
5. Provide a fault in a circuit for students doing item 4 of JS6-L3-UIII.
6. For students doing items 2 and 3 of JS7-L3-UIII, add a battery drain to the circuit being tested to ensure a bad reading.
7. Many of the activities assigned in JS1-L3-UIII through JS5-L3-UIII require items that can be purchased from an electrical supplier or from an automotive parts stores.

MODULE: ELECTRICAL SYSTEMS

UNIT III: TESTING AND DIAGNOSING ELECTRICAL CIRCUITS

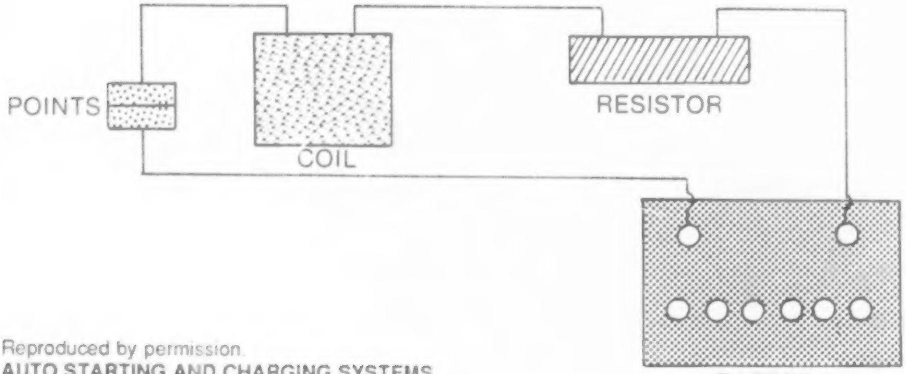
LESSON 1: CIRCUIT ARRANGEMENTS AND THEIR VARIOUS USES

I. Circuit arrangement (current paths)

  A. Components in an electrical circuit can be placed in an almost limitless number of arrangements--some simple and some very complex. The electrical circuit itself, however, is limited to three configurations: series, parallel, or series-parallel.

  B. Series circuit

    1. In a series circuit, electrical components are connected end to end, providing the current only one path.



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    2. In a series circuit, each component receives electrical current from the component before it.

    3. The resistance of the series circuit can be determined by totaling the resistance of each load.

    4. Ohm's law has been used below to find the total current of a circuit in which the resistance of each load device is known.

      a. Determining resistance of a series circuit

      $R1 + R2 + R3 = Rt$ (Ohms)

b. Example of Ohm's law used to figure series circuit resistance

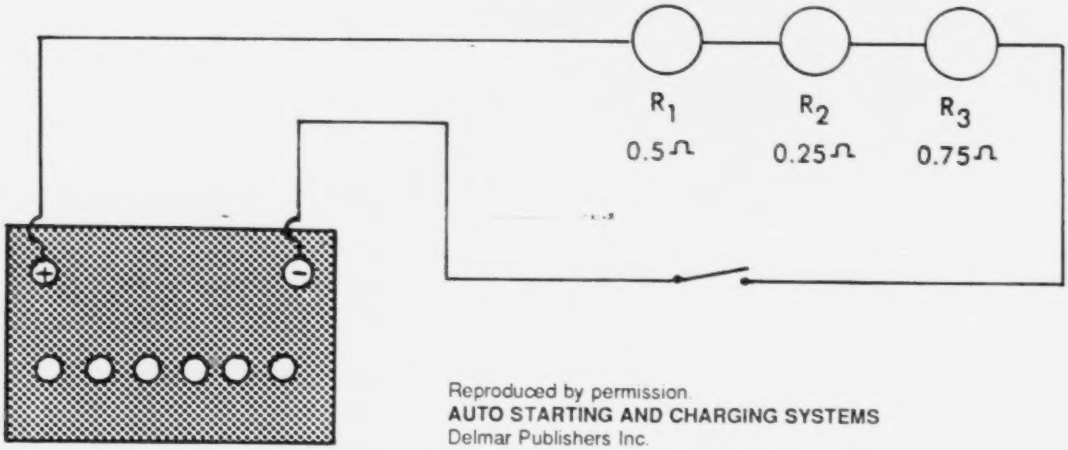
.5 + .25 + .75 = 1.5 Ohms

c. Determining the current flow of a series circuit

$$\frac{\text{Volts}}{\text{Rt (Ohms)}} = \text{Amps}$$

d Example of Ohm's law used to figure current flow in a series circuit

$$\frac{12\text{ Volts}}{1.5\text{ Ohms}} = 8\text{ Amps}$$



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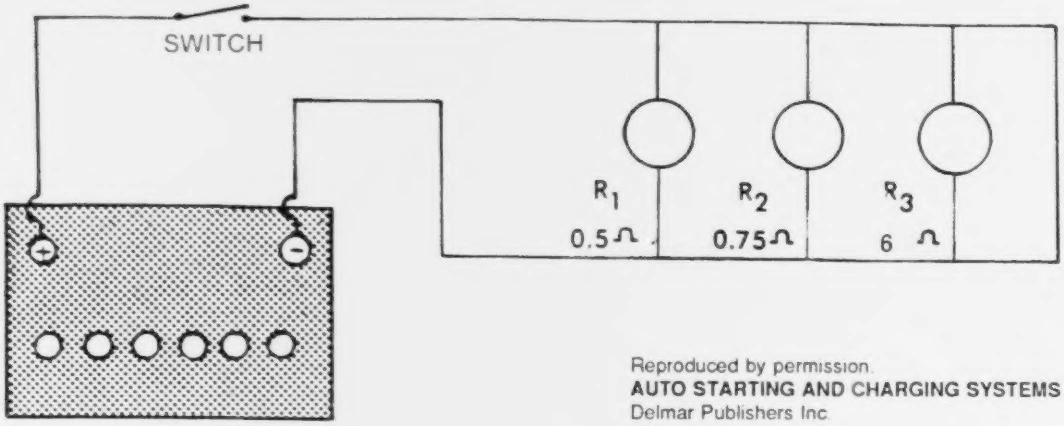
5. If any component in the series circuit fails and interrupts current flow, all components in the circuit will be denied current.

C. Parallel circuits

1. In the parallel circuit, all positive component connections are hooked to a common point, and all negative component connections are hooked to a common point.


SWITCH
+
-
R1
0.5 Ω
R2
0.75 Ω
R3
6 Ω

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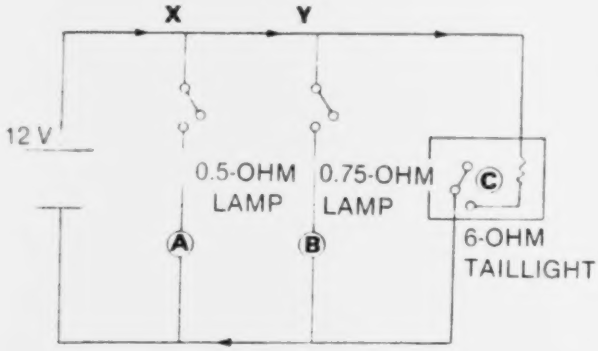
2. Each component in a parallel circuit operates independently from the other circuit components.

3. In a parallel circuit, each component has equal access to current.


X
Y
12 V
0.5-OHM LAMP
0.75-OHM LAMP
6-OHM TAILLIGHT
A
B
C

4. In a parallel circuit, the failure of one component does not affect the other components.

5. Assuming the switches are closed, the current in each component of a parallel circuit can be determined by Ohm's law (I = E/R).

For A: $\frac{\text{12 Volts}}{\text{0.5 Ohms}} = \text{24 Amps}$

For B: $\dfrac{\text{12 Volts}}{\text{0.75 Ohms}} = \text{16 Amps}$

For C: $\dfrac{\text{12 Volts}}{\text{6 Ohms}} = \text{2 Amps}$

To find the current in the line at X, remember that all electrons pass point X. That is, the current at X is

$$24 + 16 + 2 = 42 \text{ amps.}$$

The total current in a parallel circuit is the sum of individual currents.

6. Ohm's law is used below to find the total current in a circuit where the resistance of each load device is known.

   a. Determining resistance of a parallel circuit

   $$\frac{1}{\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}} = \text{Rt (Ohms)}$$

   b. Example of Ohm's law used to figure parallel circuit resistance

   $$\frac{1}{\frac{1}{.5} + \frac{1}{.75} + \frac{1}{6}} = \text{.28 Ohms}$$

   c. Determining the current flow of a series circuit

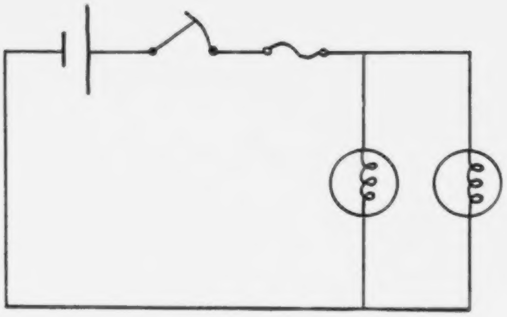
   $$\frac{\text{Volts}}{\text{Rt (Ohms)}} = \text{Amps}$$

   d. Example of Ohm's law used to figure current flow in a series circuit

   $$\frac{\text{12 Volts}}{\text{.28 Ohms}} = \text{42.8 Amps}$$

D. Series-parallel

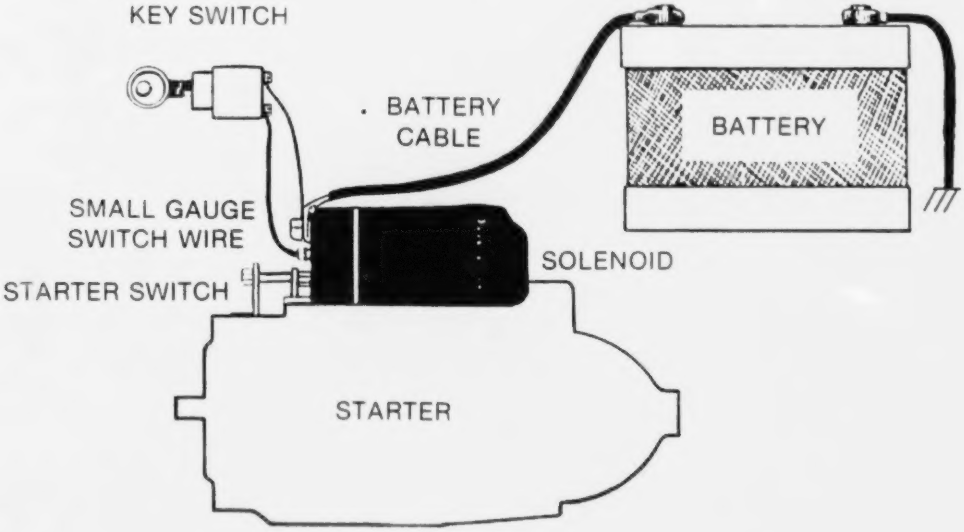
1. In a series-parallel circuit, some components are arranged in series and others in parallel.



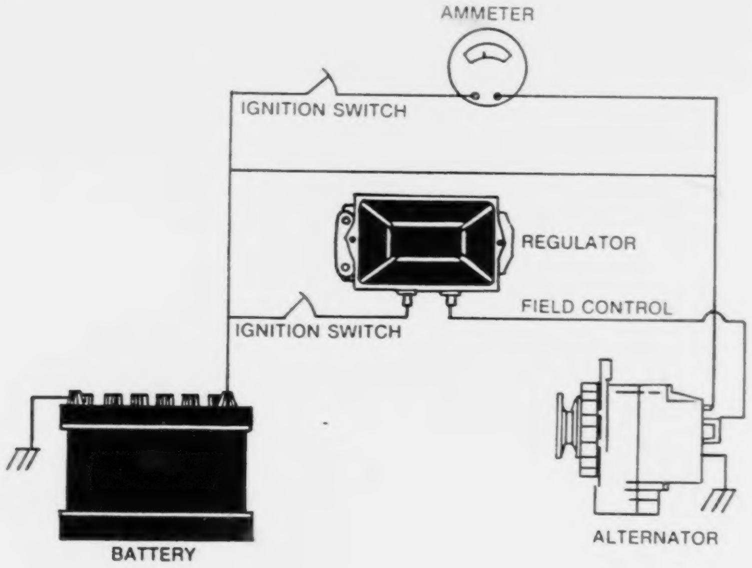
2. In the series parallel circuit, each component will function according to its position in the circuit.

II. Uses of the different circuit arrangements in the vehicle

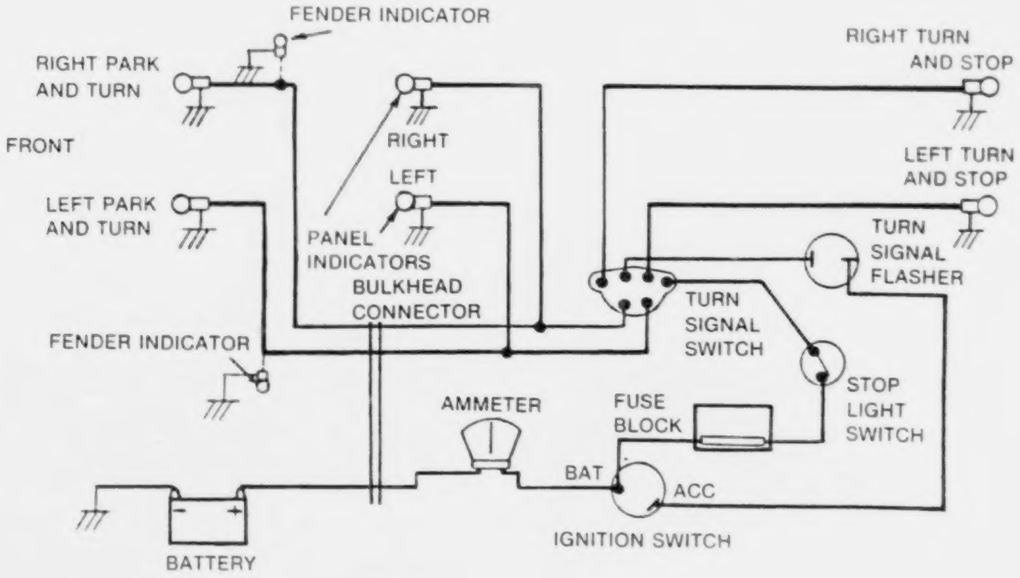
A. The starter circuit is basically a series circuit. The major starter circuit components are the mechanical relay and the starter motor. A later unit in this module covers the starter in more detail.


KEY SWITCH
BATTERY CABLE
BATTERY
SMALL GAUGE SWITCH WIRE
SOLENOID
STARTER SWITCH
STARTER

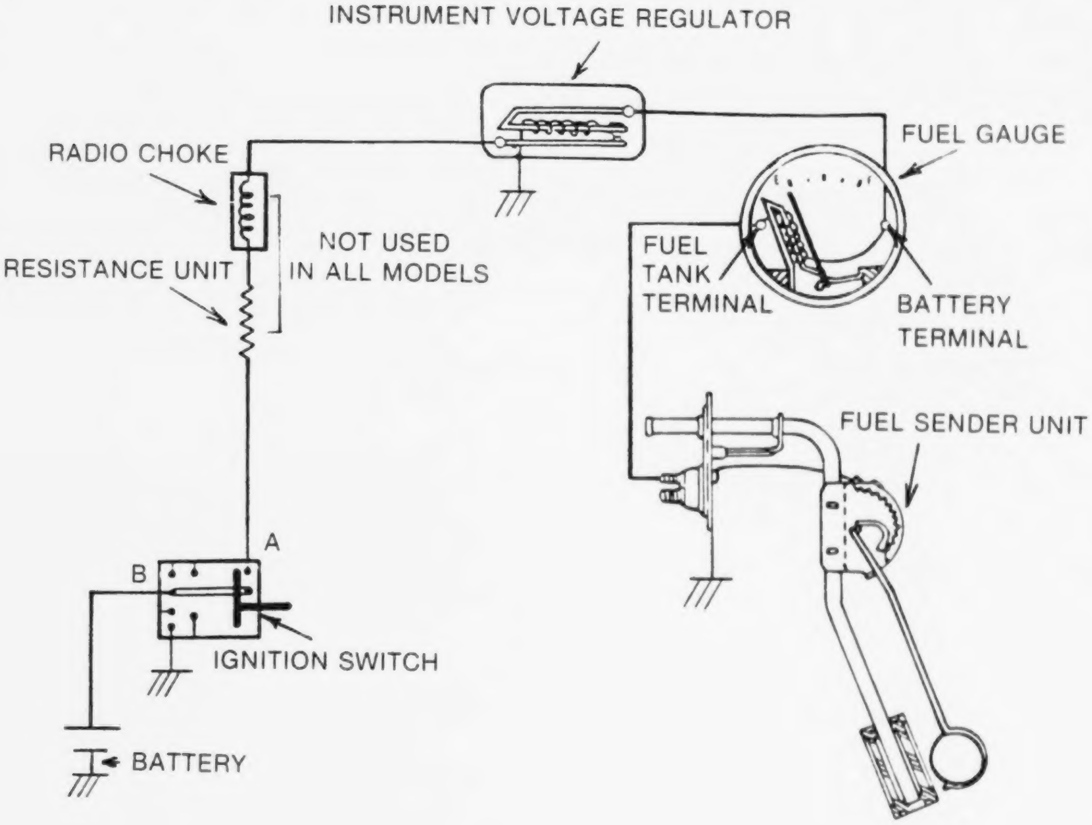
B. The charging circuit is basically a parallel circuit. In the charging circuit, however, the voltage regulator is wired in series with the alternator's field circuit.


AMMETER
IGNITION SWITCH
REGULATOR
FIELD CONTROL
IGNITION SWITCH
BATTERY
ALTERNATOR

C. The headlight circuit is basically a series-parallel configuration. The headlight switch is hooked in series to the headlights, which, in turn, are hooked in parallel.


FENDER INDICATOR
RIGHT PARK AND TURN
RIGHT TURN AND STOP
RIGHT
FRONT
LEFT
LEFT TURN AND STOP
LEFT PARK AND TURN
PANEL INDICATORS
TURN SIGNAL FLASHER
BULKHEAD CONNECTOR
TURN SIGNAL SWITCH
FENDER INDICATOR
STOP LIGHT SWITCH
AMMETER
FUSE BLOCK
BAT
ACC
IGNITION SWITCH
BATTERY

D. Accessory circuits tend to be a stand-alone series circuits. An accessory circuit is usually parallel to other accessory circuits in the automobile.


INSTRUMENT VOLTAGE REGULATOR
RADIO CHOKE
NOT USED
IN ALL MODELS
RESISTANCE UNIT
FUEL GAUGE
FUEL
TANK
TERMINAL
BATTERY
TERMINAL
FUEL SENDER UNIT
A
B
IGNITION SWITCH
BATTERY

MODULE: ELECTRICAL SYSTEMS

UNIT III: TESTING AND DIAGNOSING ELECTRICAL CIRCUITS

LESSON 2: TEST EQUIPMENT AND TEST PROCEDURES

I. Test equipment

A. A technician uses a variety of instruments to test electrical circuits. These instruments determine how well a circuit (or a component within a circuit) performs.

B. Analog meters

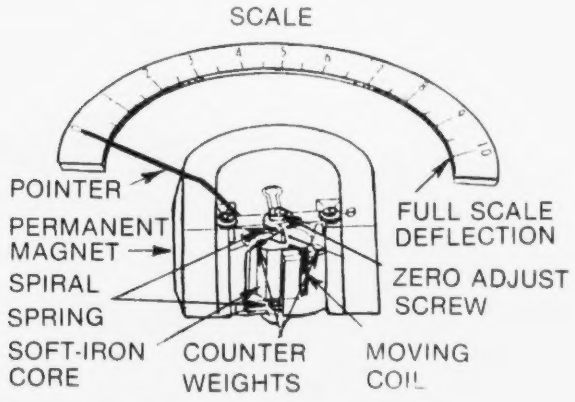
1. The analog meter is a dial-type meter with a hand that sweeps across a scale.

2. The analog meter operates in basically the same manner, whether measuring voltage, current, or resistance. However, there is a specific procedure for hooking the meter to the circuit when measuring these three aspects of the circuit.

3. The analog meter consists of a permanent magnet shaped like a horse shoe, an activating coil suspended on a pivot bearing, a tension spring, and a pointer.

a. The activating coil is suspended by pivot bearings between the sides of the permanent magnet.

b. The tension spring lightly holds the coil and pointer in the "0" position.



c. Current passing through the coil creates an opposing polarity. The pointer and coil are repelled by the magnetic difference against the tension spring, thus causing the pointer to be rotated across the dial.

d. The greater the rate of current flow, the greater the coil and pointer movement.

C. Digital meters

1. The digital meter is an electronic device that displays a numerical value on the meter face.

2. The digital meter operates in basically the same manner, whether measuring voltage, current, or resistance. However, there is a specific procedure for hooking the meter to the circuit when measuring these three aspects of the circuit.

3. The digital meter consists of a small microprocessor that displays numerical readings in response to electrical signals delivered to the meter. The range of the numerical readings is selected by the technician.

   (NOTE: Digital meters are connected to the circuit in the same fashion as analog meters.)

D. Ammeter

1. The ammeter measures current flow. In order to adapt to different levels of current flow, the ammeter uses shunts of varying levels of resistance. Different sizes of resistors (shunts) are hooked in parallel to the meter, causing more or less current to pass through the meter's coil.

   a. The reading obtained by the ammeter is related to the resistance of the shunt by parallel resistance.

   b. More current flows through shunts with low resistance, thus allowing less current to flow through the meter's coil.

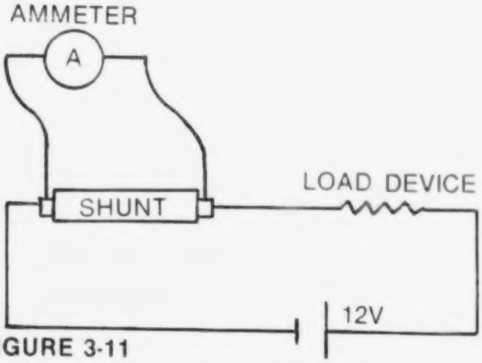


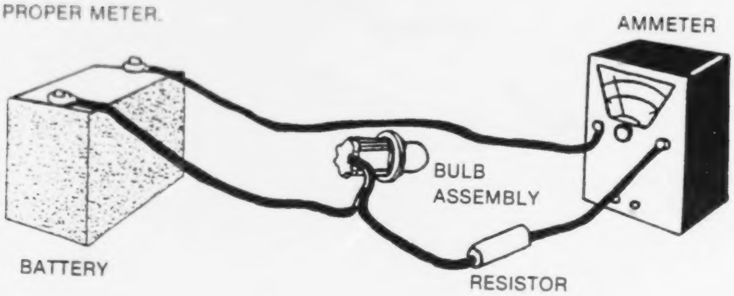
FIGURE 3-11

2. To measure current flow (amperes), the analog section of the meter is connected in parallel to the shunts (which are inside the meter). The external meter leads are then hooked in series to the circuit. This arrangement limits the amount of current flow in the analog section of the meter, thus protecting it from excessive current surges.

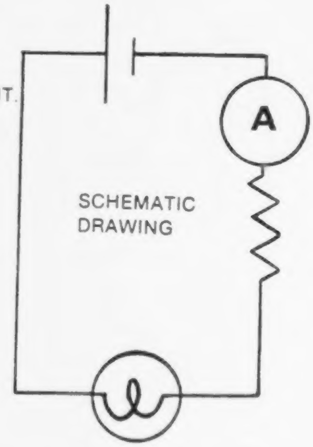
   (NOTE: A knob on the analog ammeter allows the technician to adjust the shunts to measure different levels of current flow.)

MEASURING CURRENT

SELECT PROPER METER.



TO MEASURE THE CURRENT IN A CIRCUIT,
1. BREAK THE CIRCUIT OPEN.
2. CONNECT AMMETER IN SERIES WITH THE CIRCUIT.



(**CAUTION**: To avoid damaging the meter, be sure that it can handle the expected current flow. Also make sure that the meter is connected in series with the circuit.)

E. Voltmeter

1. The voltmeter measures electron force (voltage) in a circuit.

   (NOTE: The voltmeter and ammeter are very similar in construction. The two meters differ, however, in the way their internal components are arranged. The two meters also differ in the way they are hooked to a circuit.)

2. Voltmeters are hooked in parallel to the circuit. The rate of current flow through the voltmeter is determined by the force (voltage) in the circuit.

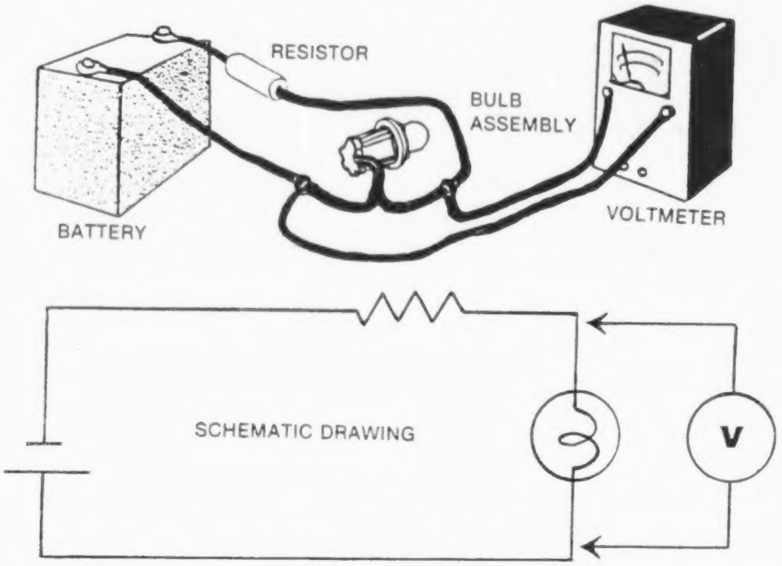
   a. The current flowing through the circuit has virtually no effect upon the voltmeter. This is because the voltmeter is outside the circuit's current path and only senses the circuit's potential voltage.

   b. Current flow through the voltmeter is related to the voltage of the circuit against the internal resistance (impedance) of the meter. The meter becomes a parallel load to the circuit being tested.

3. The range of a voltmeter can be varied by hooking its resistors in series to its coil. This reduces the voltage across the resistor and thus protects the meter from excessive current flow. The lower the resistance, the higher the current flow through the meter.

4. Suppose an ammeter shows that 5 amps of current is flowing through a circuit with 2 ohms of resistance. According to Ohm's law, 10 volts are required to push the 5 amps through the 2 ohms.

   (NOTE: A knob on the voltmeter allows the technician to change the meter's internal resistance, thus altering current flow through the meter and changing the meter's reading.)



TO MEASURE VOLTAGE, CONNECT THE VOLTMETER LEADS DIRECTLY ACROSS OR IN PARALLEL WITH THE PART BEING MEASURED.

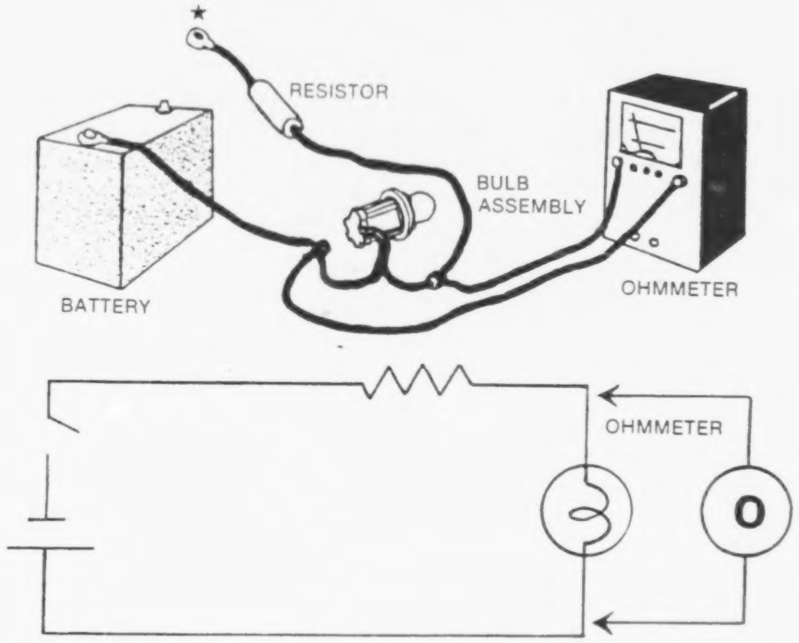
F. Ohmmeter

1. The ohmmeter measures the resistance of a circuit or its components. The ohmmeter uses a meter movement similar to that of the ammeter and voltmeter; the ohmmeter, however, contains its own power supply.

2. Before the ohmmeter can be used, the circuit's original power source must be substituted with a known force (voltage) from the ohmmeter. Because voltage, current flow, and resistance are related, an ohmmeter can determine a circuit's resistance by measuring the circuit's rate of current flow.

   (NOTE: A knob on the ohmmeter allows the technician to change the meter's internal resistance, thus altering current flow through the meter and changing the meter's reading.)

3. Increasing resistance decreases voltage to the meter and reduces meter movement.



TO MEASURE THE RESISTANCE OF A COMPONENT, CONNECT THE OHMMETER TEST LEADS DIRECTLY ACROSS OR IN PARALLEL WITH THE PART BEING MEASURED.

(**CAUTION**: Before hooking up the ohmmeter, be sure there is no power in the circuit.)

G. Multimeter

1. The multimeter contains a multirange ammeter, a multirange voltmeter, and a multirange ohmmeter. The more sophisticated the multimeter, the more functions and ranges it will have.

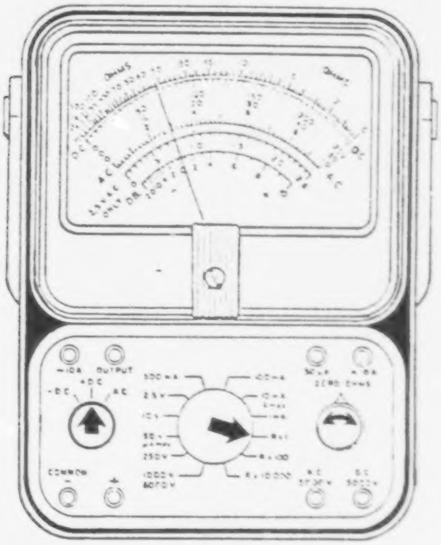
2. Terms and definitions associated with the multimeter

   a. Functions--The various operations for which the multimeter is designed. A DCV meter, for example, will measure direct current voltage.

   b. Range--The difference between the maximum and minimum values that the multimeter will measure. A 20 DCV meter, for example, will measure up to 20 volts of direct current voltage.

c. Zero position--The rest position of the multimeter's needle. Zero position is also equivalent to a complete absence of resistance. Zero position is adjusted on the meter face.

d. Ohms zero position--The position of the needle when the two meter leads are connected together. Ohms zero position is controlled by an ohms adjust knob.



3. A multimeter usually has a control knob for selecting DCV, ACV, amperes or resistance functions.

4. Some multimeters have an individual switch for selecting the range or scale of each function. On other multimeters, the function control knob allows for the selection of the range or scale of each function.

5. The meter will have a knob for adjusting the rest or zero position of the needle and an ohms zero adjustment for full needle swing.

6. Most multimeters will have several jack positions for the specific activities that the meter is designed to measure.

7. Procedure for reading the multimeter scale for volts and amps

   a. Make sure that the range selection is adequate for the highest voltage to be measured.

   b. On the meter dial, locate the highest reading for the range selected.

   c. If no scale exists for the selected range, then observe the scale that includes the first two digits of the range (for example, 500 volts would use the 50 volt scale and each reading would be 10 times smaller than the actual voltage measured.)

8. Procedure for reading the scale for resistance (ohms)

   a. Observe range selection multiplier.

   b. Locate the resistance scale on the meter dial.

   c. The meter reading will be multiplied by the range factor 10 X (RX100) = 1000 ohms.

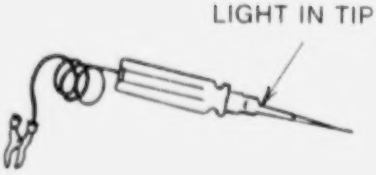
   d. An infinite reading does not necessarily mean that the circuit has no continuity. The reading may only indicate that no current is flowing in the circuit at that range setting. A higher setting may force some current through the circuit.

H. Test lights

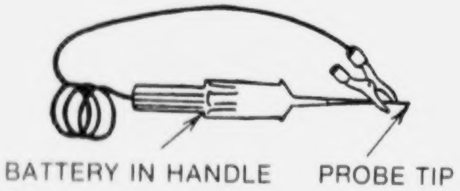
1. A basic test light uses an incandescent bulb with about 20 to 30 ohms of resistance. The test light is used to confirm the presence of voltage in a circuit.

   a. If the test light bulb comes on when hooked in parallel to a circuit, enough voltage is present. The brighter the light, the greater the circuit's voltage.

      (NOTE: A voltmeter can also confirm the presence of voltage in a circuit.)



TEST LIGHT



CONTINUITY TEST LIGHT (SELF-POWERED)

   b. Test lights are usually limited in range to 12 volts.

2. A continuity tester is a type of test light consisting of a battery and an incandescent bulb with about one ohm of resistance. A continuity tester confirms that a circuit can conduct electricity.

   (NOTE: The terms "continuity tester" and "self-powered test light" refer to the same instrument.)

   a. The continuity tester is hooked in series to the circuit.

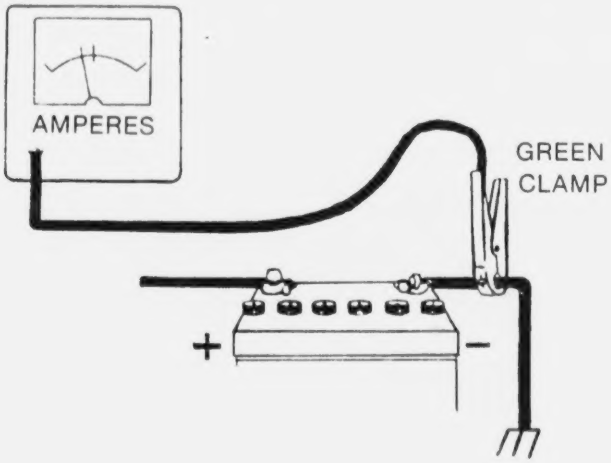
      (NOTE: An ohmmeter can also confirm a circuit's ability to conduct electricity.)

b. If the tester's bulb lights, the circuit is continuous.

I. Inductive pickup ammeter

1. The inductive ammeter uses a magnetic pickup that must be clipped to a wire in the circuit being tested. The inductive meter is actually a magnetometer (an instrument for measuring magnetic fields) with an amp scale dial.

2. A magnetic field surrounds any circuit through which current is flowing. The strength of this magnetic field is related to the circuit's rate of current flow (the greater the rate of current flow, the stronger the magnetic field). Therefore, the ammeter's magnetic pickup registers the strength of a circuit's magnetic field, which, in turn, indicates the presence of current.



J. Variable-load devices

1. When testing an electrical circuit, it is sometimes useful to produce a variable load outside the circuit. Two devices are commonly used to produce variable loads: the nichrome heater and the carbon pile.

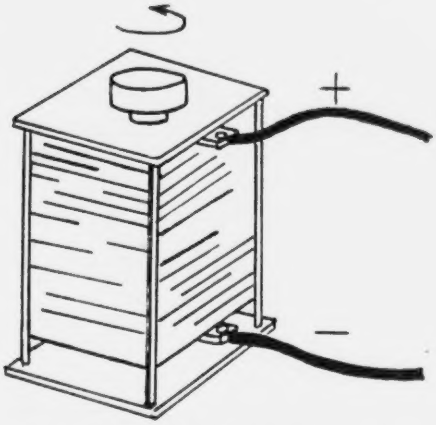
2. The nichrome heater uses a heavy-gauge, nickel-chromium coil. When energized, the heater is warmed by the current flow. The heater then places a predetermined load upon the circuit's force device (usually a battery).

   (NOTE: The nichrome heater cannot accommodate a variety of current rates; therefore, the technician will need several sizes of nichrome heaters to handle variations in current rate required for different tests.)

3. The carbon pile is the most common variable-load device. It consists of a stack of carbon plates squeezed by a compression screw.

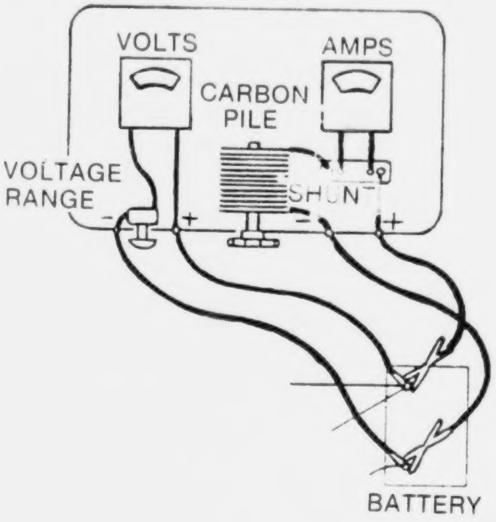
   a. As tension on the carbon pile's screw increases, the carbon plates are pressed together more tightly. As a result, current flow through the carbon pile increases.

b. As electrons collect on the plates, the load upon the force device increases. This infinitely variable load is very useful for testing circuit performance.



CARBON PILE LOAD DEVICE

BATTERY-STARTER TESTER



II Testing procedures

A. An operational test determines what parts of the circuit have failed or are operating incorrectly.

B. Tracing a circuit's current path is an important part of most test procedures. When tracing a current path, the technician should use a wiring schematic to determine the relationship between circuit components.

C. The technician may use the process of elimination to determine the most likely location of a fault in a circuit. After doing so, the technician should select the appropriate meter to test the suspected point of failure.

D. On the basis of test results, the technician will repair or replace any defective components.

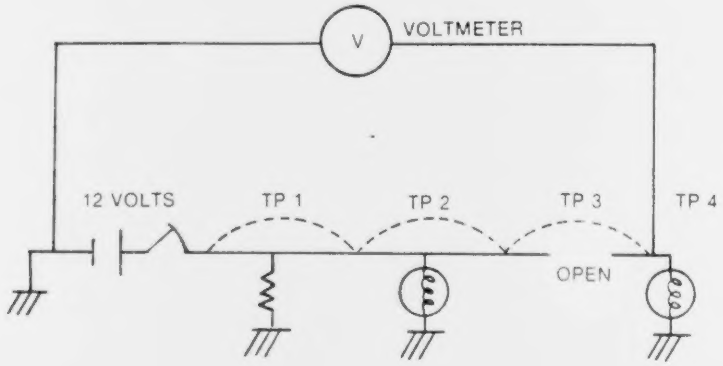
E. To confirm successful repair, the technician should test the system by operating it in all cycles.

(NOTE: Before a technician can prepare to test and repair a faulty circuit, he or she must have a reasonable understanding of how the circuit works and where its components are located. The electrical schematic is, therefore, an indispensable tool for diagnosing electrical system failure.)

III. Failure of a circuit and/or its components is caused by one of three possible electrical faults: an open, a short, or a ground. There is a specific test for detecting each fault.

A. An open circuit occurs when the current path is broken as the result of a physical gap or hole in the conductor. A blown fuse is an example of an open circuit.

(NOTE: The appropriate method of testing for opens depends upon whether the technician intends to test the entire circuit or only one of its components. A voltmeter or a test light should be used to test an entire circuit. An ohmmeter should be used to test an individual component removed from the circuit.)

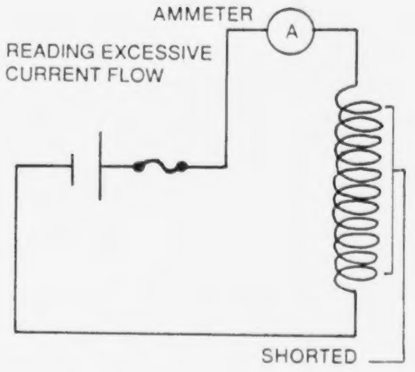


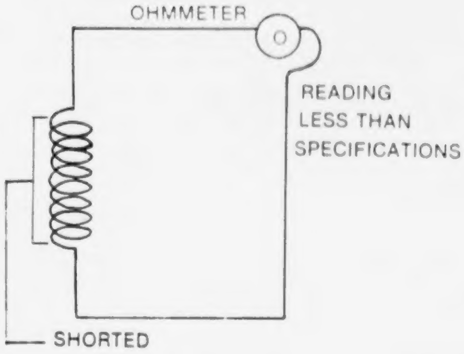
RESULTS

TP 1	12	VOLTS
TP 2	12	VOLTS
TP 3	12	VOLTS
TP 4	0	VOLTS

B. An electrical short occurs when current follows a low-resistance (shortened) path within a circuit. For example, a short would occur if the coil windings of a load device made contact with each other (this could happen if insulating material was melted or worn away). The load device would then have a short (a path of low resistance) because the coil would be reduced in length.

(NOTE: A short will create excessive current draw and interrupt the operation of electrical components.)

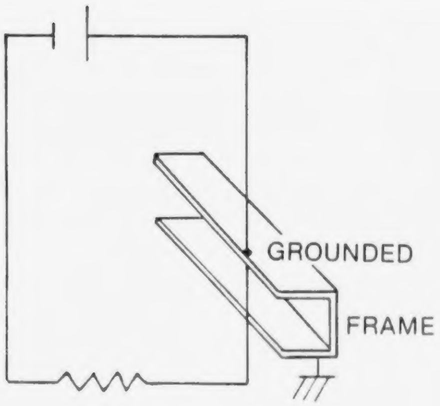

AMMETER
A
READING EXCESSIVE
CURRENT FLOW
SHORTED

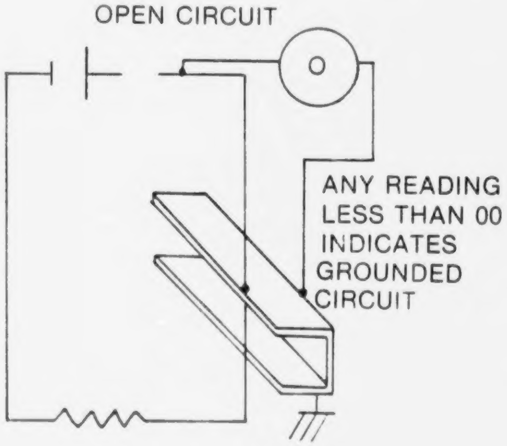

OHMMETER
O
READING
LESS THAN
SPECIFICATIONS
SHORTED

(NOTE: Either an ohmmeter or ammeter can be used to test for shorts.)

C. A ground occurs when current bypasses a circuit's load devices and simply flows from one side of the power source directly back to the other.

(NOTE: The ohmmeter is a good instrument for testing for grounds.)


GROUNDED
FRAME


OPEN CIRCUIT
O
ANY READING
LESS THAN 00
INDICATES
GROUNDED
CIRCUIT

MODULE: ELECTRICAL SYSTEMS

UNIT III: TESTING AND DIAGNOSING ELECTRICAL CIRCUITS

LESSON 3: SAFETY IN TESTING ELECTRICAL SYSTEMS

I. Personal safety precautions

A. Automotive batteries can produce over 700 amps of current. The by-product of such current flow is heat, hydrogen, and acid outgassing--all of which are harmful to humans. Always consider the following safety precautions when working on or around an automotive battery.

1. High-current discharge within an electrical system can overheat conductors and create a fire hazard.

2. Batteries contain sulfuric acid, which will severely burn flesh. Always protect eyes and skin when working around batteries. Clothing and vehicle paint can also be damaged by sulfuric acid.

3. High battery activity will cause the escape of hydrogen gas, which is highly explosive. An exploding battery will throw debris and sulfuric acid in all directions.

B. Electrical arcing can occur anywhere in an electrical system where high-potential voltage contacts a source of low-potential voltage. Arcing can cause fuel or hydrogen vapor to burn and/or explode.

(**CAUTION:** When opening an electrical circuit, always disconnect the negative or ground cable first. To prevent arcing, connect the negative cable last.)

C. The modern ignition distributor produces very high voltage discharge. Though it is unlikely that the discharge itself would harm the technician, his or her involuntary response to the shock can result in cracked elbows and knuckles.

II. Many of the hazards technicians face when working with electrical systems also pose a danger to the vehicle. The technician can protect the vehicle by taking the precautions outlined below.

A. Safety precautions to be taken before repair

1. Check under the hood for exposed wiring, heat damage, or the presence of fuel and acid. Also check for fuel and acid in the hoodliner.

2. Consider whether the repair will involve heavy current flow or arcing.

3. Plan a test sequence.

B. Safety precautions to be taken during repair

1. Avoid unintentional grounding or shorting of circuit components.

2. Avoid testing unprotected circuits if possible.

3. Use a grounding wrist strap to maintain equivalent ground potential when working with sensitive electronic components.

4. Avoid loading sensitive electronic circuits with test lights or other load-test instruments (analog meters or low-impedance digital meters).

C. Safety precautions to be taken after repair

1. Always activate the repaired circuit and all circuits related to it to ensure they are fully operational.

2. Visually inspect repaired systems for defective insulation and proper routing of wires.

MODULE: ELECTRICAL SYSTEMS

MEASURING VOLTAGE IN A CIRCUIT

Equipment:

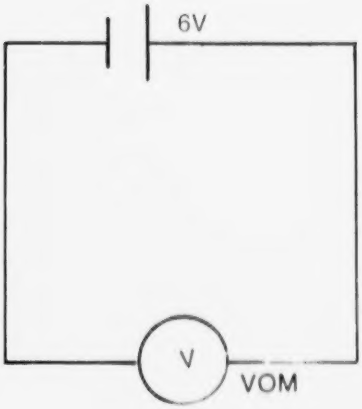
Two 6-volt, dry-cell batteries
Two automotive bulbs and sockets
Analog VOM
Digital VOM
Two jumper leads
Safety glasses

Procedure:

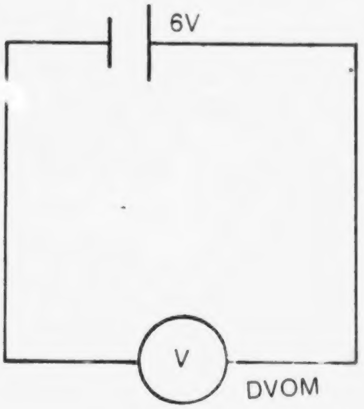
Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. — — — —

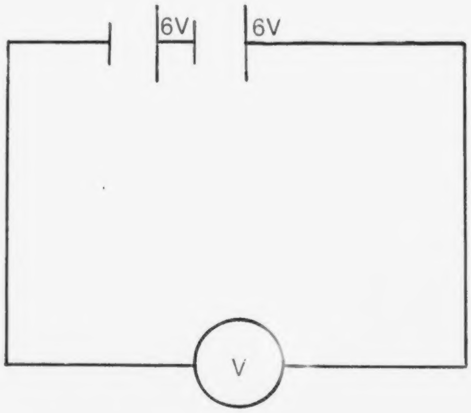
2. Using an analog VOM, perform a voltage check on a single 6-volt battery. Use proper meter procedure. Be sure to observe correct polarity. Record observations. — — — —



3. Using a digital VOM, perform a voltage check on a single 6-volt battery. Use proper meter procedure. Be sure to observe correct polarity. Record observations. — — — —

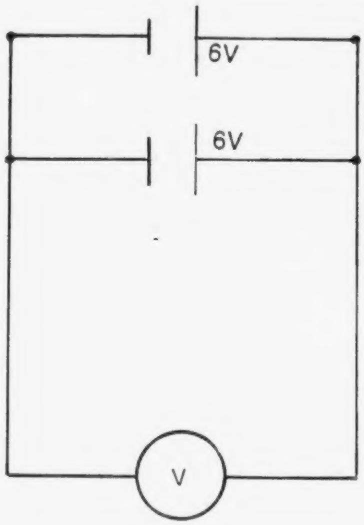


4. Wire two 6-volt batteries in series. Measure their combined voltage using both an analog and digital VOM. Be sure to observe correct polarity. Record observations. — — — —



VOM ______
DVOM ______

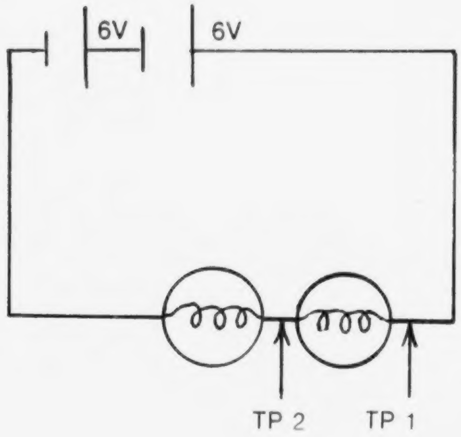
5. Wire two 6-volt batteries in parallel. Measure combined voltage using an analog and digital VOM. Be sure to observe correct polarity. Record observations. — — — —



VOM ______

DVOM ______

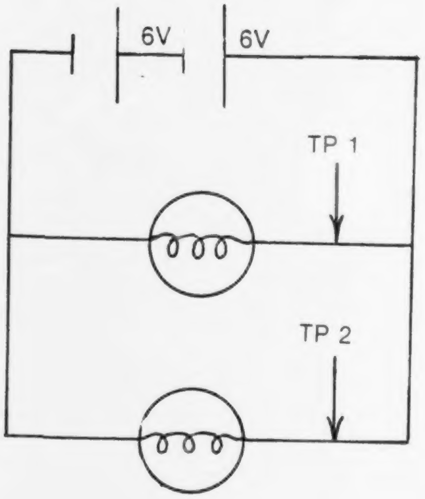
6. Wire two automotive bulbs and sockets that are wired in series to two 6-volt batteries that are wired in series. Measure voltage at test points (TP) 1 and 2. Be sure to observe polarity. Record observations. — — — —



TP 1 ______

TP 2 ______

7. Wire two automotive bulbs and sockets in parallel to two 6-volt batteries wired in series. Measure voltage at test points (TP) 1 and 2. Be sure to observe polarity. Record observations. — — — —



TP 1 ________

TP 2 ________

Average of above evaluations* — — — —

(*This is a partial evaluation for Competency D4. Final evaluation for D4 will be made at the end of JS9-L3-UIII.)

JS2-L3-UIII

MODULE: ELECTRICAL SYSTEMS

MEASURING RESISTANCE IN A CIRCUIT

Equipment:

Two automotive bulbs and sockets
Analog or digital VOM
Diode
Throttle position sensor (potentiometer)
Safety glasses

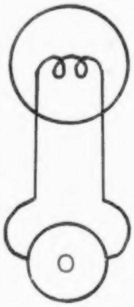
Procedure:

Evaluation
3 2 1 N

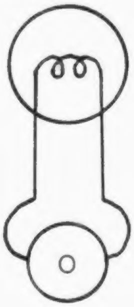
1. Wear safety glasses while doing all procedures on this job sheet. — — — —

2. Using a VOM, perform a resistance check on bulbs A and B. Record observations. — — — —

BULB A



BULB B

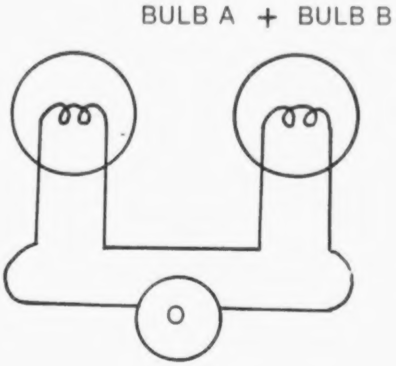


Bulb A ________

Bulb B ________

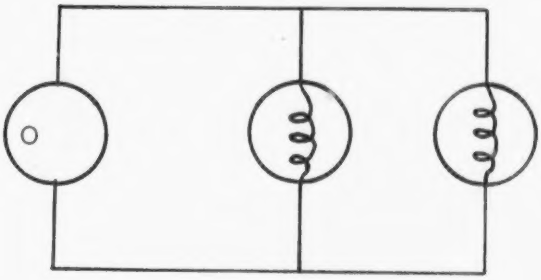
3. Using Ohm's law, calculate the total circuit series resistance. Use the readings from item 1 above. Record observations. — — — —

4. Connect bulbs A and B in series and, using a VOM, measure the total circuit resistance. Record observations. _ _ _ _

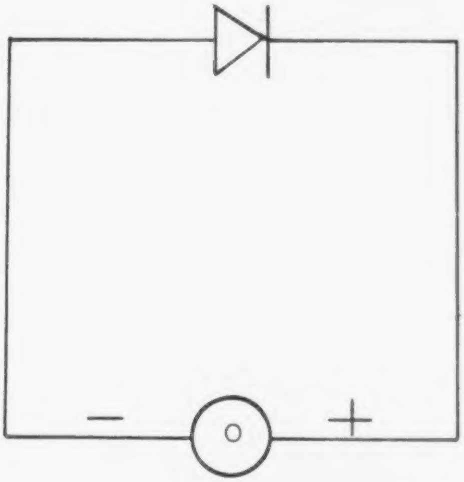


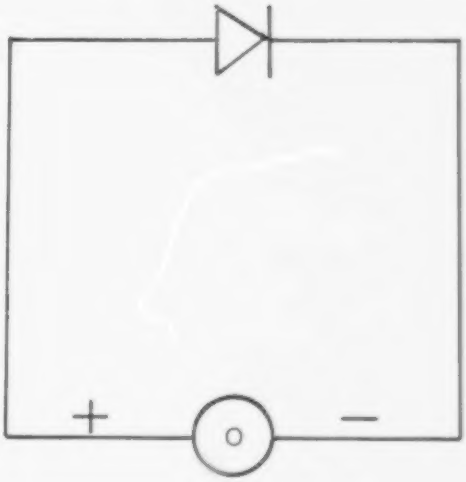
5. Using Ohm's law, calculate the total circuit parallel resistance. Use the readings from item 1 above. Record observations. _ _ _ _

6. Connect bulbs A and B in parallel and, using a VOM, measure the total circuit resistance. Record observations. _ _ _ _



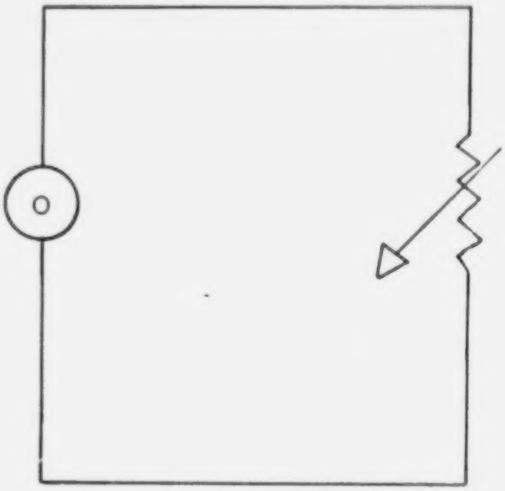
7. Using a multirange ohmmeter, perform a resistance test across a diode. First perform the test with the ohmmeter leads in one direction. Next, reverse the leads and perform the test again. Record observations. — — — —





	Test #1		Test #2
R x 1	______	R x 1	______
R x 100	______	R x 100	______
R x 1K	______	R x 1K	______

8. Perform a resistance test across a potentiometer (throttle position sensor). Slowly sweep the potentiometer and watch the VOM change. Record observations. _ _ _ _



Initial reading ________

1/2 potentiometer sweep ________

Full potentiometer sweep ________

Average of above evaluations* _ _ _ _

(*This is a partial evaluation for Competency D3. Final evaluation for D3 will be made at the end of JS11-L3-UIII.)

MODULE: ELECTRICAL SYSTEMS

MEASURING CURRENT IN A CIRCUIT

Equipment:

Two 6-volt batteries
Direct reading ammeter, 0-15 amps minimum
Two automotive bulbs and sockets
Two jumper leads
Shunt bar
Safety glasses

Evaluation
3 2 1 N

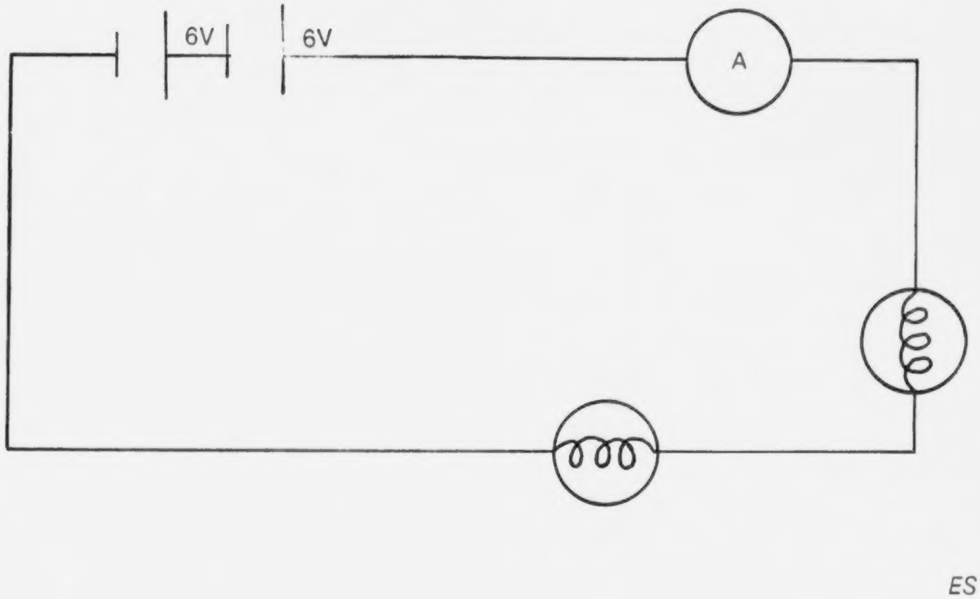
Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

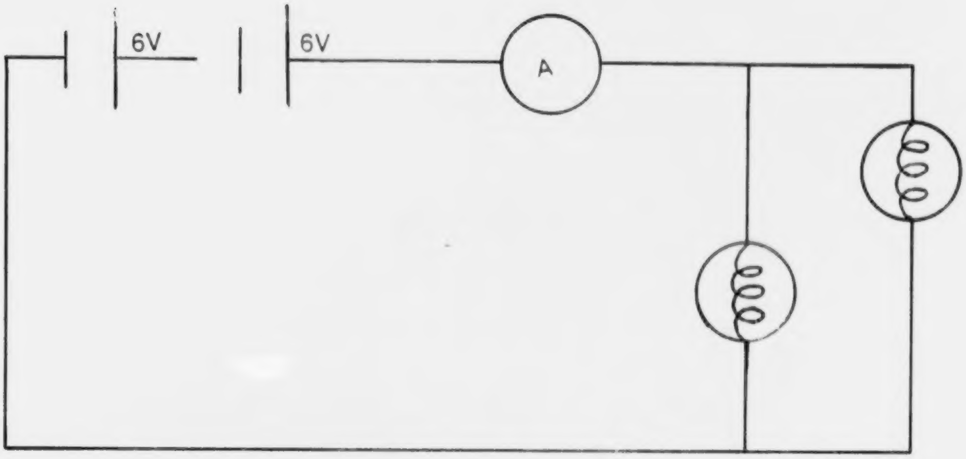
2. Using a direct-reading ammeter, measure current flow in the circuits shown below. Follow the procedure outlined below. __ __ __ __

    a. Wire two automotive bulbs and sockets in series to two 6-volt batteries wired in series. Measure the current in the circuit. Be sure to observe polarity. Record observations.

FIG 3-32



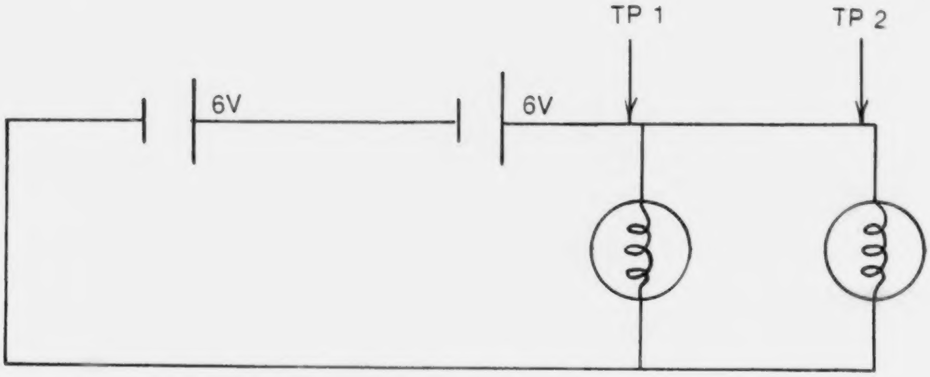
b. Wire two automotive bulbs and sockets in parallel to two 6-volt batteries wired in series. Measure the current flow in the circuit. Be sure to observe polarity. Record observations.



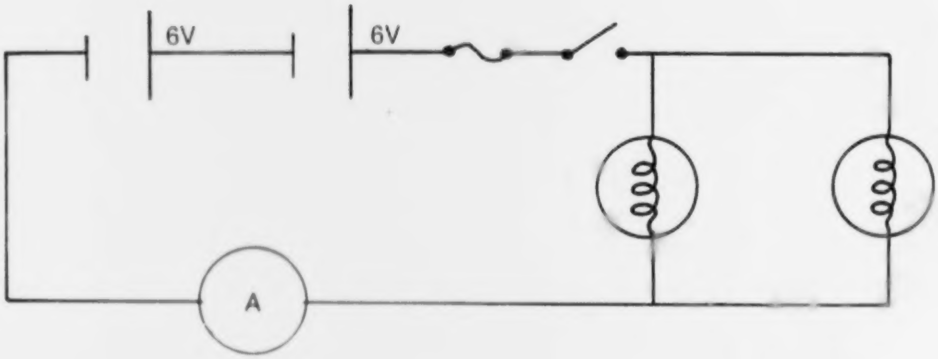
3. Using an inductive ammeter, measure current flow in the circuits shown below. Follow the procedure outlined below. — — — —

(NOTE: See instructor for operating instructions for the particular ammeter that will be used.)

a. Wire two automotive bulbs and sockets in series to two 6-volt batteries wired in series. Measure the current in the circuit. Be sure to observe polarity. Record observations.



b. Wire two automotive bulbs and sockets in parallel to two 6-volt batteries wired in series. Measure the current flow in the circuit. Be sure to observe polarity. Record observations.



Average of above evaluations* ____

(*This is a partial evaluation for Competency D5. Final evaluation for D5 will be made at the end of JS10-L3-UIII.)

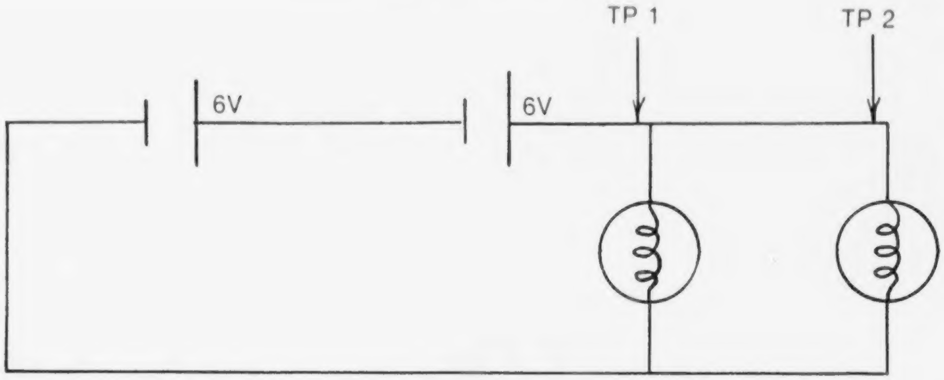
MODULE: ELECTRICAL SYSTEMS

DETERMINING CIRCUIT VOLTAGE AND CONTINUITY USING A TEST LIGHT

Equipment:

Two 6-volt batteries
Test light
Two automotive bulbs and sockets
Two jumper leads
Safety glasses

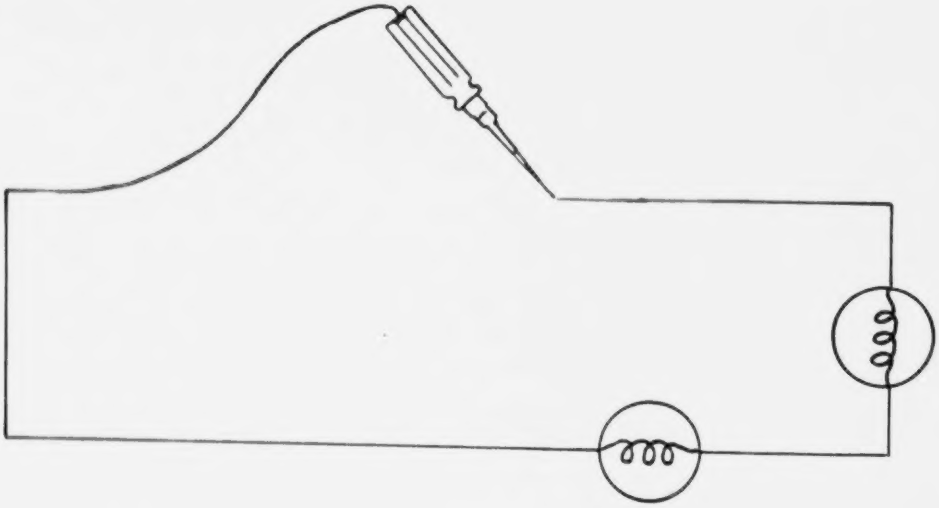
Procedure:	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2. Wire two automotive bulbs and sockets in parallel to two 6-volt batteries wired in series. Using a test light, check for voltage at the test points (TP) indicated. Record observations.	__ __ __ __



Voltage apparent at TP 1 Yes ____ No ____

Voltage apparent at TP 2 Yes ____ No ____

3. Wire two automotive bulbs and sockets in series. Using a self-powered test light, check the circuit for continuity. Record observations. ____



Is the circuit continuous? Yes ___ No ___

Average of above evaluations* ____

(*This is a partial evaluation for Competency D1. Final evaluation for D1 will be made at the end of JS11-L3-UIII.)

MODULE: ELECTRICAL SYSTEMS

FAULT TESTING PROCEDURE

Equipment:

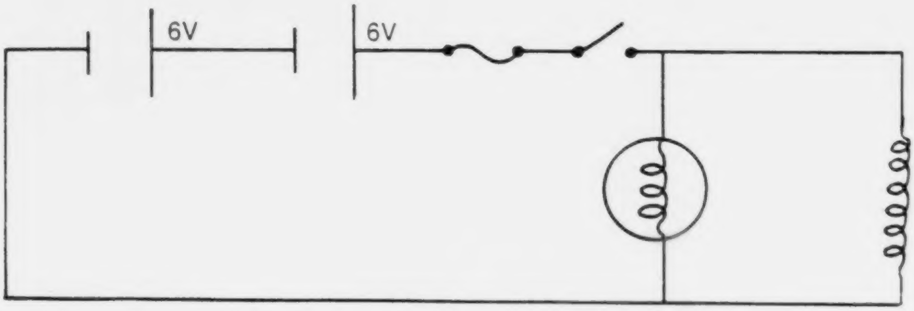
Six feet of varnished small-gauge wire
Two 6-volt batteries
Two jumpers
Two automotive bulbs and sockets
Single pole single throw switch
VOM
One 1-amp fuse
Test light
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. — — — —

2. Set up circuit according to the diagram below. Have the instructor place a fault in the circuit. To determine the fault and the needed repairs, perform the test procedure outlined below. — — — —



a. Perform operational test and determine results.

b. Trace current path and list the relationship of components in the circuit.

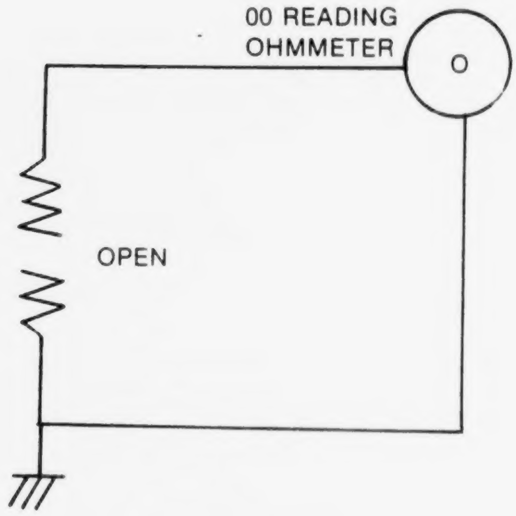
c. Isolate fault and select appropriate meter for testing.

d. Perform test procedures.

e. Repair or replace malfunctioning component.

f. Perform another operational test to determine if the system is now functional. Record observations.

3. Set up circuit according to the diagram below. Have the instructor place a fault in the circuit. To determine the fault and needed repairs, perform the test procedure outlined below. — — — —



a. Perform an operational test and determine results.

b. Trace current path and list the relationship of the components in the circuit.

c. Isolate fault and select appropriate meter for testing.

d. Perform test procedures.

e. Repair or replace malfunctioning component.

f. Perform another operational test to determine if system is now functional. Record observations.

Average of above evaluations* ____

(*This is a partial evaluation for Competency D2. Final evaluation for D2 will be made at the end of JS6-L2-UIV.)

JS6-L3-UIII

MODULE: ELECTRICAL SYSTEMS

CHECKING CONTINUITY IN AUTOMOTIVE ELECTRICAL CIRCUITS

Equipment:

VOM
Test light
Selected vehicle circuit
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. _ _ _ _

2. Have the instructor select a specific electrical circuit. Using a test light, perform a continuity test on the circuit. Follow the procedure outlined below. _ _ _ _

   a. Attach test light to ground.

   b. Energize circuit.

   c. Probe wire along circuit with a test light to confirm the presence of current. Record observations.

3. Perform a continuity test on the circuit by checking voltage with either a digital or analog meter. _ _ _ _

   a. Set up meter for parallel measure.

   b. Energize circuit.

   c. Confirm the presence of voltage by probing the wire along the circuit and taking a battery voltage reading. Record observations.

4. Perform continuity test by checking the circuit's resistance with a digital or analog meter. — — — —

   a. Set up meter for resistance test.

   b. Be sure that circuit is de-energized.

   c. Probe the wire along the circuit to confirm the presence of a low-resistance current path. Record observations.

Average of above evaluations* — — — —

(*This is a partial evaluation for Competency D1. Final evaluation of D1 will be made at the end of JS11-L3-UIII.)

MODULE: ELECTRICAL SYSTEMS

CHECKING FOR OPENS, SHORTS, AND GROUNDS IN AN AUTOMOTIVE ELECTRICAL CIRCUIT

Equipment:

VOM
Ammeter
Selected vehicle circuit
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. _ _ _ _
2. Test for battery current drain using a digital or analog meter. Follow the procedure outlined below. _ _ _ _
    a. Set up meter for resistance test.
    b. Disconnect negative (ground terminal) from battery.
    c. Attach meter between negative cable and positive cable.
    d. Disconnect any nonswitched circuits (clock, digital radio, computer, etc.).

       (NOTE: To disconnect nonswitched circuits, remove the fuse.)
    e. Turn off all systems.
    f. Record any readings below infinite.
    g. Using Ohm's law, calculate battery current drain and determine whether it is below .5 amps.
    h. Record observations and recommend repairs.

3. Test for battery current drain by using an ammeter. Follow the procedure outlined below. __ __ __ __

   a. Set up meter for series or inductive ampere measure.

   b. Turn off all systems.

   c. Record any ampere readings and determine if circuit resistance is below 5 amps.

4. Test fusible link using a digital or analog VOM. Follow the procedure outlined below. __ __ __ __

   a. Set up meter for resistance.

   b. Probe fusible link to determine its continuity. Record observations.

5. Test circuit breaker for opens using a voltmeter. Follow the procedure outlined below. __ __ __ __

   a. Set up meter for resistance test.

   b. Remove circuit breaker from panel.

   c. Perform resistance test across the breaker with low scale voltmeter. Record observations.

6. Test fuse for opens with a test light. Follow procedure outlined below. __ __ __ __

   a. Set up test light.

   b. Probe both sides of the fuse to check for voltage. Record observations.

7. Test a load device for shorts using an ohmmeter. Follow procedure outlined below. — — — —

   a. Set up meter for resistance test.

   b. Have instructor select a load device (wiper motor, ignition coil, etc.).

   c. Perform resistance test on load.

   d. Use Ohm's law to calculate current.

   e. Compare current reading to specifications of the load device or to the maximum fuse size allowed. Record observations.

Average of above evaluations* — — — —

(*This is a partial evaluation for Competency D2. Final evaluation for D2 will be made at the end of JS6-L2-UIV.)

MODULE: ELECTRICAL SYSTEMS

MEASURING RESISTANCE IN AN AUTOMOTIVE ELECTRICAL CIRCUIT

Equipment:

VOM
Selected vehicle circuit
Safety glasses

Procedure:	Evaluation 3	2	1	N
1. Wear safety glasses while doing all procedures on this job sheet.	___	___	___	___
2. Have the instructor select a vehicle circuit or component. Measure resistance in the circuit using an ohmmeter.*	___	___	___	___

   a. Set up meter for resistance check.

   b. Perform resistance check across component or circuit.

   c. Record recommended repairs and observations.

(*This is a partial evaluation for Competency D3. Final evaluation for D3 will be made at the end of JS11-L3-UIII.)

MODULE: ELECTRICAL SYSTEMS

MEASURING VOLTS IN AN AUTOMOTIVE ELECTRICAL CIRCUIT

Equipment:

VOM
Selected vehicle circuit
Safety glasses

Procedure:	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	— — — —
2. Have the instructor select a vehicle circuit. Test the voltage in the circuit with a voltmeter. Use the procedure outlined below*.	— — — —

   a. Set up meter for parallel voltage test.

   b. Energize circuit.

   c. Perform voltage test on selected circuit. Record observations.

(*This is a partial evaluation for Competency D4. Final evaluation for D4 will be made at the end of this Job Sheet.)

FINAL EVALUATION INSTRUCTIONS

I. Using the spaces provided below, average the final evaluation of JS1-L3-UIII with JS9-L3-UIII to determine the student's final evaluation for Competency D4.

	Evaluation 3 2 1 N
JS1-L3-UIII	— — — —
JS9-L3-UIII	— — — —
Final evaluation for Competency D4	— — — —

JS10-L3-UIII

MODULE: ELECTRICAL SYSTEMS

MEASURING CURRENT IN AN AUTOMOTIVE ELECTRICAL CIRCUIT

Equipment:

Ammeter
Selected vehicle circuit
Safety glasses

Procedure:	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	___ ___ ___ ___
2. Have the instructor select a vehicle circuit. Measure the current in the circuit with an ammeter. Use the procedure outlined below.*	___ ___ ___ ___

a. Set up meter for series or inductive test.

b. Hook up meter in series or connect inductive pick-up.

c. Energize circuit.

d. Measure current draw. Record observations.

(*This is a partial evaluation for Competency D5. Final evaluation for D5 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency D5 by averaging the final evaluations of JS3-L3-UIII and JS10-L3-UIII. Use the spaces provided below.

	Evaluation 3 2 1 N
JS3-L3-UIII	___ ___ ___ ___
JS10-L3-UIII	___ ___ ___ ___
Final evaluation for Competency D5	___ ___ ___ ___

JS11-L3-UIII

MODULE: ELECTRICAL SYSTEMS

INSPECTING, TESTING, AND REPLACING FUSIBLE LINKS, CIRCUIT BREAKERS, AND FUSES IN AN AUTOMOTIVE ELECTRICAL CIRCUIT

Equipment:

Test light
Ohmmeter
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, check and replace fuses on a vehicle selected by the instructor. ___ ___ ___ ___

   a. Connect one end of a test light to a suitable ground.

   b. Turn on the appropriate switches to energize all circuits protected by fuses.

   c. Touch the other end of the test light to both ends of the fuse to verify that the fuse is in good condition.

   d. Verify that the fuses in each circuit are of the correct amperage. (Use owner's manual or service manual to determine the amperage specifications for each fuse.) Record observations.

CIRCUIT	FUSE#	AMPS SPEC	TEST LIGHT OK NOT OK	CORRECT AMPS

   e. Replace defective fuses and retest. Record observations.

3. Following the procedure outlined below, check and replace fusible links on a vehicle selected by the instructor. ____

   a. Locate all fusible links in the vehicle and, using a service manual, identify the circuits which they are protecting. Record observations.

   b. Conduct a visual inspection of all fusible links in the vehicle and verify that all links are in good condition. (The condition of fusible links can also be determined by checking the circuit with a test light.) Record observations.

   c. Replace defective fusible links.

4. Following the procedure outlined below, check and replace circuit breakers on a vehicle selected by the instructor. ____

   a. Locate all circuit breakers in the vehicle.

   b. Identify which circuits each of the circuit breakers protect.

   c. Verify that each circuit breaker is of the appropriate amperage.

   (NOTE: If necessary, consult a service manual when working on items a, b, and c above.)

   d. Connect one end of the test light to a suitable ground.

   e. Turn on the appropriate switches to energize all circuits protected by circuit breakers.

   f. Verify that the circuit breaker is in good condition by touching the other end of the test light to both terminals of the circuit breaker. Record observations.

CIRCUIT	CIRCUIT BREAKER#	AMPS SPEC	TEST LIGHT		CORRECT AMPS
			OK	NOT OK	

g. Replace defective circuit breakers and retest. Record observations.

— — — —

Average of above evaluations*

(*This is a partial evaluation for Competencies D1,D2, and D3. Final evaluations for D1 and D3 will be made at the end of this Job Sheet. Final evaluation for Competency D2 will be made at the end of JS6-L2-UIV.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency D1 by averaging the final evaluations from JS4-L3-UIII, JS6-L3-UIII, and JS11-L3-UIII. Determine the student's final evaluation for Competency D3, by averaging the final evaluations from JS2-L3-UIII, JS8-L3-UIII, and JS11-L3-UIII. Use the spaces provided below.

	Evaluation 3 2 1 N
A. Evaluating Competency D1	
JS4-L3-UIII	— — — —
JS6-L3-UIII	— — — —
JS11-L3-UIII	— — — —
Final evaluation for Competency D1	— — — —

B. Evaluating Competency D3

JS2-L3-UIII — — — —

JS8-L3-UIII — — — —

JS11-L3-UIII — — — —

Final evaluation for Competency D3 — — — —

MODULE: ELECTRICAL SYSTEMS

UNIT III: TESTING AND DIAGNOSING ELECTRICAL SYSTEMS

UNIT III TEST

PART I. TESTING AND DIAGNOSING ELECTRICAL SYSTEMS

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 1. If a technician knows how a circuit is arranged, he or she can more easily repair or test it.

____ 2. In the series circuit, components are connected end to end so that the current has a single path.

____ 3. Each component in a series circuit operates independently of other components in the circuit.

____ 4. Total resistance of a series circuit equals the sum of the individual resistances of the circuit.

____ 5. In a parallel circuit, all positive component connections are hooked to a common point, and all negative component connections are hooked to a common point.

____ 6. The total current in a parallel circuit equals half of the total of the individual currents.

____ 7. If any component in a parallel circuit fails, all other components in the circuit will be denied current flow.

____ 8. Though a series-parallel circuit will always contain some components that are arranged in series, most of the components will usually be arranged in parallel.

____ 9. Each component of the series-parallel circuit will function according to its position in the circuit.

____ 10. The starter circuit is basically a parallel circuit, the major components of which are a mechanical relay and the starter motor.

____ 11. The voltage regulator is arranged in series with the field circuit of the alternator.

____ 12. The headlight circuit is a series-parallel circuit in which the light switch is wired in series to the headlights, which are wired in parallel.

____ 13. The accessories circuit arrangement may be a stand-alone series circuit.

____ 14. The accessories circuit arrangement may be parallel to other load components in a shared circuit.

SECTION B. Select the best answer from the five choices listed.

____ 15. In an analog meter, the tension spring lightly holds the coil and pointer in the

a. "1" position.
b. "-1" position.
c. "0" position.
d. "off" position.
e. "neutral" position.

____ 16. When current passes through the coil of an analog meter, an opposing polarity is created. The pointer and the coil then

a. are repelled by the magnetic force.
b. are pulled together by the magnetic force.
c. activate a light in the meter.
d. pass high-level current back and forth.
e. pass low-level current back and forth.

____ 17. The ammeter uses the analog meter arrangement and shunt resistors to vary the range of the meter for different levels of current flow. Resistors (shunts) of different sizes are hooked in

a. series to the meter.
b. parallel to the meter.
c. series-parallel to the meter.
d series to a relay device before being hooked to the meter.
e. series-parallel to a relay device before being hooked to the meter.

____ 18. The technician can change the range of most ammeters by

a. replacing the ammeter's shunts.
b. connecting a booster device to the ammeter's shunts.
c. connecting transistors to the ammeter's shunts.
d. connecting a battery to the ammeter's shunts.
e. adjusting the knob or switch on the ammeter.

____ 19. Voltmeters are hooked in

a. parallel to the circuit.
b. series to the circuit.
c. series-parallel to the circuit.
d. all of the above.
e. none of the above.

____ 20. Assume an ammeter shows 3 amps of current flow through a circuit that has 2 ohms of resistance. According to Ohm's law the amount of voltage pushing the 3 amps through 4 ohms would be

a. 12 volts.
b. 7 volts.
c. 1 volt.
d. 8 volts.
e. 19 volts.

____ 21. An ohmmeter measures

a. electron force.
b. current flow.
c. resistance.
d. intensity of electrical arcs.
e. intensity of magnetic fields.

____ 22. The ohmmeter differs from other meters in that it

a. is an analog device.
b. is not sensitive to intense heat.
c. contains its own power supply.
d. can only be used with copper wire circuits.
e. can only be used in series-parallel circuits.

____ 23. The multimeter is an instrument that contains

a. a multirange ammeter.
b. a multirange voltmeter.
c. a multirange ohmmeter.
d. all of the above.
e. none of the above.

____ 24. The range of a multimeter is defined as the

a. difference between the maximum and minimum value that the meter will measure.
b. difference between the maximum and minimum value that the meter will measure, multiplied by four.
c. difference between the maximum and minimum value that the meter will measure, divided by four.
d. maximum value that the meter will measure.
e. maximum number of electrical components that can be tested by a multimeter at one time.

____ 25. Test lights are used to

a. confirm the presence of voltage in a circuit.
b. confirm the presence of carbon conductors in a circuit.
c. detect the presence of burned or melted insulation.
d. create a magnetic polarity so that other meters can be used.
e. confirm the presence of magnetic polarity.

____ 26. Continuity testers are used to

a. confirm that a circuit contains a coil.
b. confirm that a circuit can conduct electricity.
c. give the technician an idea of what components are contained in a circuit.
d. detect arcing in a circuit.
e. measure the magnetic field surrounding a circuit.

____ 27. Inductive ammeters use a magnetic pickup to measure current flow. The inductive ammeter works upon the principle that

- a. the absence of magnetic polarity in a circuit signifies the presence of dangerously high voltage.
- b. no magnetic field can be detected around a conductor through which current is flowing.
- c. magnetic poles will be reversed around a conductor through which electricity is flowing.
- d. a magnetic field will be produced around a conductor through which current is flowing.
- e. arcing will occur in a circuit with a low magnetic field.

____ 28. Two devices that can produce a load outside a circuit are the

- a. nichrome heater and the carbon pile.
- b. nichrome heater and the printed circuit board.
- c. carbon pile and the printed circuit board.
- d. carbon pile and the incandescent bulb.
- e. nichrome heater and the incandescent bulb.

SECTION C. Read each of the below statements made by technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.

____ 29. Technician I says that a wiring schematic is extremely useful in tracing the current path of a circuit.

Technician II says that it is normal for a small amount of hydrogen gas to leak from a battery.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 30. Technician I says that wiring schematics are usually available only for circuits that include four or more components.

Technician II says that hydrogen gas is highly explosive.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 31. Technician I says that sulfuric acid in battery electrolyte is hazardous to any organic material.

Technician II says that sulfuric acid in battery electrolyte is hazardous to vehicle paint.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 32. Technician I says that arcing can occur almost anywhere in the electrical system.

Technician II says that arcing is usually the result of worn or thin electrical insulation around a conductor.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 33. Technician I says that, during removal of a vehicle's battery, arcing can be prevented by disconnecting the negative battery cable first.

Technician II says that arcing occurs most often in circuits surrounded by strong magnetic fields.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 34. Technician I says that high-voltage discharge produced by a vehicle's ignition distributor is usually not strong enough to harm electrical components.

Technician II says that high-voltage discharge produced by a vehicle's ignition distributor is powerful enough to burn large areas of unprotected skin.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 35. Technician I says that some automotive batteries can produce over 700 amps of current.

Technician II says that high-current discharge can overheat conductors and create a fire hazard.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 36. Technician I says that, during a repair of sensitive electrical systems, equivalent ground potential should be maintained with a grounding wrist strap.

Technician II says that the loading of sensitive electronic systems with test lights or other load instruments should be avoided during repair.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 37. Technician I says that the testing of unprotected circuits should be avoided if possible.

Technician II says that unintentional grounding or shorting of circuit components should be avoided during repair.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of ______ on Part I of the Unit III Test in order to receive an evaluation for Competencies D1-D5.)

PART II. CHECKING FOR OPENS, SHORTS, AND GROUNDS

SECTION A. Read each of the below statements made by technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.

____ 38. Technician I says that, when isolating a fault in a circuit, the process of elimination is a good way to detect the likely point of failure.

Technician II says that insulation on a wire running to a blown fuse will usually be melted or burned.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 39. Technician I says that an open occurs when the current path in a circuit has been broken by a physical gap in the conductor.

Technician II says that opens usually occur only in printed circuit boards.

Who is right
(a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 40. Technician I says that a voltmeter would be a good choice for testing the complete circuit for opens while it is energized.

Technician II says that an ohmmeter is a good choice for testing individual circuit components for opens when the component is out of the circuit.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 41. Technician I says that a short occurs when a circuit's load devices have been bypassed and current is flowing from one side of the power source back to the other.

Technician II says that a short occurs when the circuit's current finds a low-resistance (shortened) path, causing the circuit to fail from excessive current draw.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 42. Technician I says that, when a short occurs in a coil, the coil windings will have higher resistance because the coil is now wider.

Technician II says that, when a short occurs in a coil, the coil windings will have a higher resistance because the coil is now longer.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 43. Technician I says that an ohmmeter is a good instrument for testing for shorts.

Technician II says that an ammeter is a good instrument for testing for shorts.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 44. Technician I says that, when a circuit is grounded, it may still be able to perform limited electrical work.

Technician II says that a grounded circuit occurs when the load devices in the circuit have been bypassed and the current is flowing from one side of the power source to the other.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 45. Technician I says that an ohmmeter is a good instrument for testing for grounds.

Technician II says that a voltmeter is a good instrument for testing for grounds.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of ____ on Part II of the Unit III Test in order to receive an evaluation for Competency D2.)

ANSWERS TO UNIT III TEST

1.	t
2.	t
3.	f
4.	t
5.	t
6.	f
7.	f
8.	f
9.	t
10.	f
11.	t
12.	t
13.	t
14.	t
15.	c
16.	a
17.	b
18.	e
19.	a
20.	a
21.	c
22.	c
23.	d
24.	a
25.	a
26.	b
27.	d
28.	a
29.	a
30.	b
31.	c
32.	c
33.	a
34.	a
35.	c
36.	c
37.	c
38.	a
39.	a
40.	c
41.	c
42.	d
43.	c
44.	c
45.	a

MODULE: ELECTRICAL SYSTEMS

UNIT IV: BATTERY DIAGNOSIS AND SERVICE

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose and service automotive batteries. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with both the battery and the procedures for testing the battery (Competencies E1-E4, Part I of the Unit IV Test.)

II. Identify the components of a battery and the characteristics of battery construction (Competencies E1-E4, Part I of the Unit IV Test).

III. Identify characteristics of battery operation (Competencies E1-E4, Part I of the Unit IV Test).

IV. Identify procedures for inspecting and maintaining the battery (Competency E1, Part II of the Unit IV Test).

V. Identify procedures for cleaning a battery (Competency E1, Part II of the Unit IV Test).

Lesson 2.

I. Identify the terms and definitions associated with battery condition tests (Competency E2, Part III of the Unit IV Test).

II. Identify the procedures and equipment used in testing the condition of a battery (Competency E2, Part III of the Unit IV Test).

III. Demonstrate the ability to:

- a. Check battery for surface leakage (Competency E2, JS1-L2-UIV).
- b. Clean battery case and terminals (Competency E1, JS2-L2-UIV).
- c. Measure battery state of charge (Competency E2, JS3-L2-UIV).
- d. Load test the battery (Competency E2, JS4-L2-UIV).
- e. Perform a three-minute charge test (Competency E2, JS5-L2-UIV).
- f. Check battery for external current drain (Competency D2, JS6-L2-UIV).

Lesson 3.

I. Identify the characteristics by which batteries are classified (Competencies E1-E4, Part I of the Unit IV Test).

II. Identify the procedures for charging a battery (Competency E4, Part IV of the Unit IV Test).

III. Identify the procedures for installing a battery (Competency E4, Part IV of the Unit IV Test).

IV. Identify procedures for jump starting a vehicle (Competency E3, Part V of the Unit IV Test).

V. Demonstrate the ability to:

   a. Charge a battery (Competency E4, JS1-L3-UIV).

   b. Jump start a vehicle (Competency E3, JS2-L3-UIV).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks F008-F014.

MODULE: ELECTRICAL SYSTEMS

UNIT IV: BATTERY DIAGNOSIS AND SERVICE

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Information outline

1. Lesson 1: THE CONSTRUCTION, OPERATION, AND MAINTENANCE OF THE AUTOMOTIVE BATTERY

    a. Information outline

2. Lesson 2: AUTOMOTIVE BATTERY CONDITION TESTS

    a. Information outline

    b. Job sheets

        JS1-L2-UIV: Checking an Automotive Battery for Surface Leakage
        JS2-L2-UIV: Cleaning the Case and Terminals of an Automotive Battery
        JS3-L2-UIV: Measuring State of Charge of an Automotive Battery
        JS4-L2-UIV: Load Testing an Automotive Battery
        JS5-L2-UIV: Performing a Three-minute Charge Test on an Automotive Battery
        JS6-L2-UIV: Checking for External Current Drain on an Automotive Battery

3. Lesson 3: CHARGING AND INSTALLING AN AUTOMOTIVE BATTERY AND JUMP STARTING A VEHICLE

    a. Information outline

    b. Assignment sheets

        AS1-L3-UIV: Automotive Battery Service

    c. Job sheets

        JS1-L3-UIV: Charging an Automotive Battery
        JS2-L3-UIV: Jump Starting a Vehicle

E. Unit test

F. Answers to unit test

REFERENCES

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Chrysler Motors. 1988 Service Manual: Electrical, Fuel, and Emission Systems: Front Wheel Drive Car.

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DeKryger, William, J., Robert T Kovacik, and Saverio G. Bono. Auto Mechanics Theory and Service. Cincinnati: South-Western Publishing Company, 1986.

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Downing, Ronald. Automotive Electrical Systems and Tune-up Procedures: Instructor's Guide. Module 5 of Auto Mechanics. University of Missouri-Columbia: Instructional Materials Laboratory, 1981.

Mitchell Information Services, Inc. 1986 Domestic Cars Tune up Mechanical Service and Repair. San Diego: Mitchell Information Services, Inc., 1986.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L3-UIV before taking the Unit IV Test.

2. Items 3 through 6 on JS3-L2-UIV cover several methods for measuring a battery's state of charge. The instructor should assign procedures that he wishes the students to perform. Any or all of the procedures may be assigned.

3. Items 3 through 5 on JS6-L2-UIV cover several methods for measuring external current drain on a battery. The instructor should assign procedures that he wishes the students to perform. Any or all of the procedures may be assigned.

B. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

1. Battery and Cranking System, Principles of Operation (AM-84-400), 1984.

2. Battery and Starting System Testing (AM-84-420), 1984.

MODULE: ELECTRICAL SYSTEMS

UNIT IV: BATTERY DIAGNOSIS AND SERVICE

LESSON 1: THE CONSTRUCTION, OPERATION, AND MAINTENANCE OF THE AUTOMOTIVE BATTERY

I. Terms and definitions

A. Ambient temperature--The temperature of the air surrounding an object. Ambient temperature can be measured with either a Celsius or Fahrenheit thermometer.

B. Ampere hour--A unit of measure for battery capacity.

C. Battery--A chemical device that produces electricity.

D. Capacity--The quantity of electrons that can be delivered by an electrical system or electrical device. Capacity is related to time x amp/hr.

E. Discharge--The flow of electrons from a source.

F. Electrode--The conductors in a cell.

G. Electrolyte--A mixture of sulfuric acid and water that produces a chemical action within the battery. Electrolyte is often referred to as battery acid.

H. Element--A group of negative and positive plates. The plates are arranged so that, at full charge, they can deliver about 2.2 volts.

I. Hydrogen gas--A by-product of the chemical charging of a battery. Hydrogen gas is highly explosive.

J. Lead--A malleable metal that is a useful conductor. Lead's chemical symbol is pb. Lead is sometimes referred to as sponge lead.

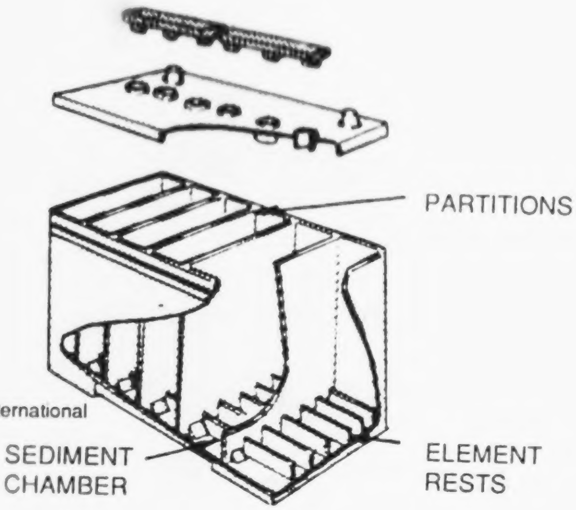
K. Lead dioxide--A combination of lead and oxygen. Lead dioxide's chemical symbol is pbo2.

L. Specific gravity--The weight of a liquid compared to pure water.

M. Sulfuric acid--A liquid acid which forms electrolyte when mixed with water.

II. Battery construction

A. An automotive battery case is constructed of ABS plastic or some similar material. The case contains divisions, which hold battery elements. The top of the case is vented to a liquid recovery system, which allows outgassing without the loss of electrolyte.



Courtesy of Battery Council International

B. Terminal post

1. A plus sign (+) is used to identify the battery's positive terminal post. The positive post is slightly larger than the negative post. Batteries also have a side terminal.

2. A minus sign (-) is used to identify the battery's negative terminal post.

C. Water can be added to nonsealed (serviceable) batteries through a filling tube. A ring at the bottom of the tube marks the battery's "full" level.

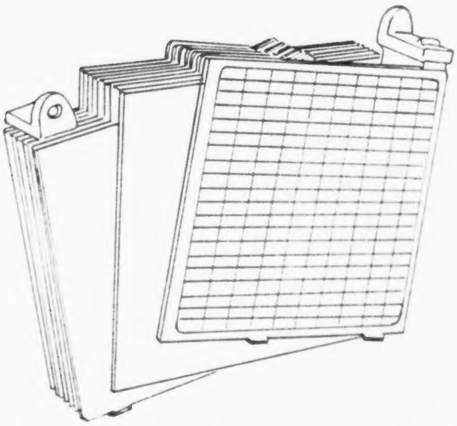
(NOTE: Only distilled water or water of low mineral content should be added to the battery.)

(NOTE: Filling tubes are found only on serviceable batteries.)

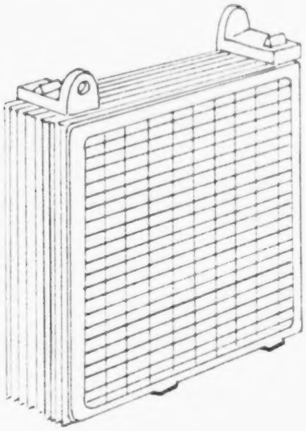
D. Battery cells

1. Battery cells are made up of lead and lead dioxide grid plates, which are suspended by a strap. In the cell, a lead (pb) plate is followed by a separator, which, in turn, is followed by a lead peroxide (pbso4) plate. This arrangement is repeated throughout the cell.

PLATE GROUPS



ASSEMBLED ELEMENT



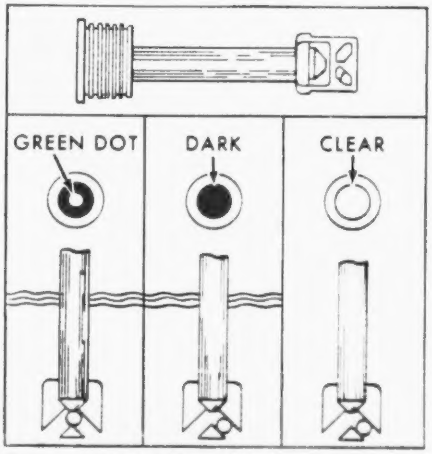
Courtesy of Battery Council International

2. Electrolyte causes the chemical action that charges or discharges the plates. Electrolyte consists of 40% sulfuric acid and 60% water.

3. A sediment chamber is an open space beneath the cell plates. The chamber collects debris from cell breakdown. If not collected, this debris would cause cells to short.

4. A cell connector is an internal lead connection between cell groups. The battery voltage is increased by connecting the cells together.

5. A state-of-charge indicator can be found on some nonserviceable batteries. The indicator is green when battery charge is above 65% and dark when charge is below 65%. If the indicator is clear, the battery is low on electrolyte and should be replaced.



Courtesy of Delco Remy Division

III. Battery operation

A. A battery does not store electricity. Instead chemical action in the battery produces electricity.

B. Battery discharge occurs when current flows from the battery (usually to a load). During discharge the positive and negative battery plates interact with electrolyte to cause a chemical action that, in turn, produces electricity. This process is described below.

1. As the battery discharges, lead (pb) in the active material of the positive plate combines with sulfate (SO_4) from sulfuric acid in the electrolyte. This process transforms the material in the positive plate into lead sulfate ($PbSO_4$). Oxygen (O) given off by this transformation combines with hydrogen (H_2) from the sulfuric acid to produce water (H_2O) which combines with the electrolyte.

2. A similar reaction takes- place simultaneously at the negative plate. Lead (Pb) in the active material of the negative plate combines with sulfate (SO_4) from the sulfuric acid in electrolyte to produce lead sulfate ($PbSO_4$). During discharge, therefore, both the positive and negative plates are producing lead sulfate.

3. During battery discharge water formed in the cell is added to the electrolyte. At the same time sulfate is being removed from the electrolyte. As a result, the electrolyte is diluted and its specific gravity is lowered.

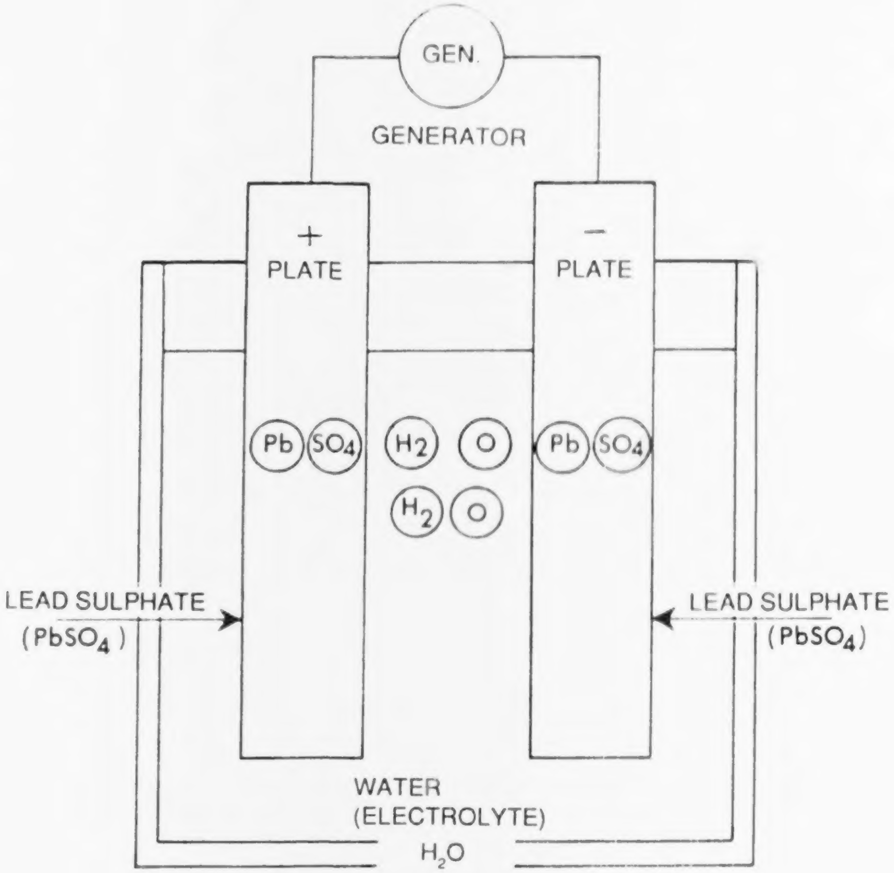
   (NOTE: The specific gravity of a battery's electrolyte becomes lower as the battery discharges. A hydrometer can be used to determine the specific gravity of the electrolyte and thereby reveal the battery's state of charge.)

4. As the battery discharges, the material in both the positive and negative plates produces lead sulfate ($PbSO_4$) and becomes more alike. The battery's electrolyte is also diluted.

   (NOTE: The battery's ability to produce current depends on the difference between the negative and positive plates and a high concentration of sulfuric acid in the electrolyte. Therefore, the process of discharging will eventually leave the battery unable to produce any current.)

C. After a battery is discharged, the chemical action must be reversed to restore the battery's ability to produce current. This is done by means of a charging system or battery charger. The process of charging is described below.

CHARGING


GEN.
GENERATOR
+
PLATE
−
PLATE
Pb
SO_4
H_2
O
Pb
SO_4
H_2
O
LEAD SULPHATE
($PbSO_4$)
LEAD SULPHATE
($PbSO_4$)
WATER
(ELECTROLYTE)
H_2O

SIMPLE LEAD - ACID STORAGE BATTERY

1. During battery charging, lead sulfate (pbSO4) on the positive and negative plates must be transformed to its original condition.

   a. Lead sulfate on the negative plates is replaced with lead (pb).

   b. Lead sulfate on the positive plates is transformed to lead dioxide (pbO2).

2. During battery charging, electrolyte (which, in a discharged battery, is similar to pure water) combines with sulfate (SO4) given up by the plates and thus regains a high content of sulfuric acid (H2SO4).

(**CAUTION:** Batteries release hydrogen and oxygen while discharging. Keep batteries away from open flames or sparks, which can cause the battery to explode.)

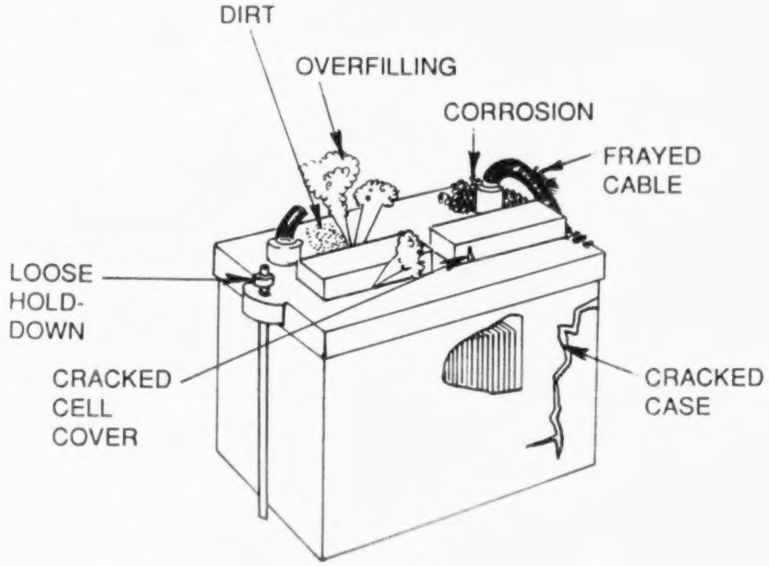
(**CAUTION:** Although electrolyte gives up sulfuric acid during battery discharge [and becomes similar to pure water], it should never be taken internally. Even in its weakest state, electrolyte is poisonous.)

IV. Procedures for inspecting and maintaining battery components and current delivery systems

A. The battery case

1. Inspect the case for cracks, abrasions, or warping caused by excessive heat.

BATTERY VISUAL CHECKS



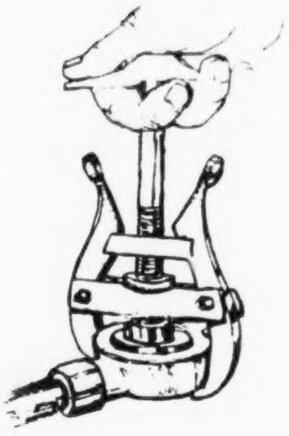
2. Make sure that the hold-down clamp is in place.

3. Clean corrosion from the battery compartment.

B. Battery cable ends

1. Remove clamp-type cable ends with a puller.

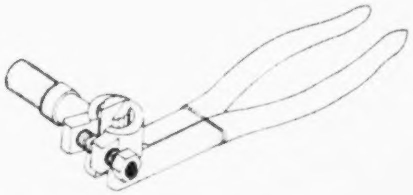
(**CAUTION:** Never twist the clamp. Twisting can break the electrical connection between the post and the cell connector.)



2. Replace corroded nuts and bolts on the cable clamps.

3. Clean cable clamps with a wire brush or scraper specifically designed for this purpose.

4. Never pound the cable clamp onto the battery post. Using a reamer/spreader, make the cable clamp wide enough to slide onto the battery post. Pounding on the post with pliers could break the seal between the post and case, allowing acid to leak onto the post and cable end.



Courtesy of Battery Council International

5. Do not over tighten side post cables. Most manufacturers recommend that terminals be tightened to approximately 60-90 In.Lbs. of torque.

C. Battery cables and terminal eyes

1. If cable ends are badly corroded or if cable insulation is damaged, the entire cable should be replaced. Route new cable through hangers or clamps to prevent contact with engine parts that may be excessively hot or moving and vibrating.

2. If the terminals are deteriorated, severely corroded or stretched out of shape, they should be replaced. Use quality replacement terminals.

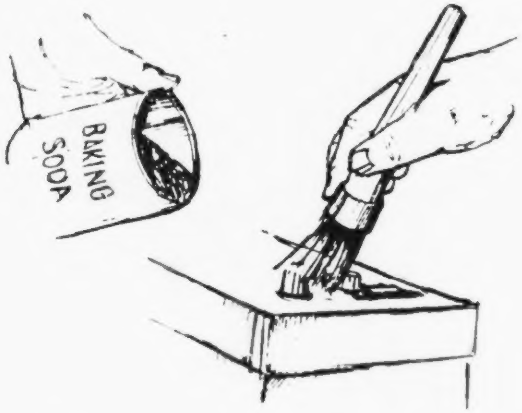
3. Use lock washer on terminal eyes to prevent loosening. Clean eye bolt and nuts to ensure a good electrical connection.

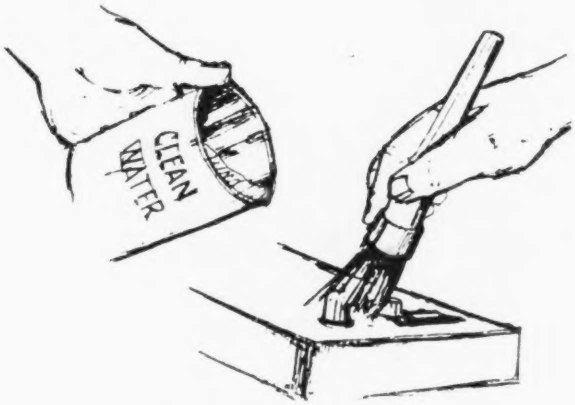
V. Cleaning the battery

A. To determine if a battery top needs to be cleaned, test for current drain across the battery top. Connect one voltmeter lead to a battery post and the other to the battery top. The voltmeter should give a reading of 0 volts. Any reading above 0 indicates that the battery top needs to be cleaned.

B. Procedure for cleaning a battery top

1. Mix a paste of baking soda and water and brush it on the battery top.



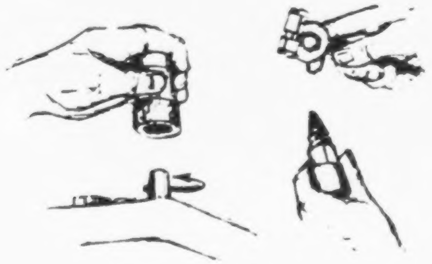


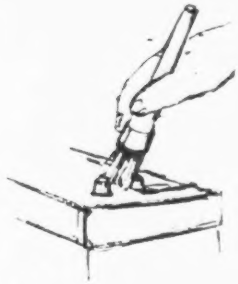
2. Wait until the acid is neutralized and then thoroughly wash the top with a liberal amount of water.

(NOTE: Avoid getting the cleaning solution or the neutralized acid inside serviceable batteries.)

C. Procedure for cleaning cable ends and posts

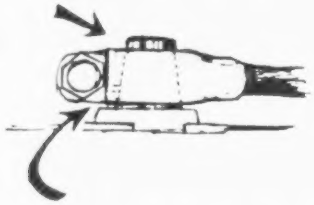
1. Using a battery cleaning brush, clean the cable and post surfaces until they shine.





2. True any rounded cable or post surfaces with a battery reamer/spreader.

3. When installing the terminal, make sure that the taper on the terminal matches the post. Tighten bolts to 60-90 in.lbs. Observe that the cable end still has a small gap in the clamp. If it is touching, remove the cable and file the gap wider.



4. Apply anticorrosion paste if desired.

MODULE: ELECTRICAL SYSTEMS

UNIT IV: BATTERY DIAGNOSIS AND SERVICE

LESSON 2: AUTOMOTIVE BATTERY CONDITION TESTS

I. Terms and definitions

A. Battery load test--A test used to determine the battery's ability to supply a specific amount of amperes based upon its original amp hours or cold-cranking amperes capacity.

B. Battery-starter tester--A tester that combines volt-amp gauges, a carbon pile, and sufficient leads to conduct a variety of starter, charging and battery system tests. The battery-starter tester can also be referred to as a VAT tester.

C. Battery static-drain test--A test in which the technician uses an ammeter to measure the amount of current that drains from the battery when all electrical load devices are de-energized. A battery static drain test should not exceed .5 amperes.

D. Carbon pile tester--A device that produces a variable load on a battery.

E. Hydrometer--A device for testing the specific gravity of a liquid based upon the liquid's density. The hydrometer is used to determine state of charge in batteries.

F. Inductive probe--A device that measures the intensity of the magnetic field around a live circuit and then uses this measurement to determine the amount of amperes flowing through the circuit.

G. Open-circuit voltage test--A test that determines battery state of charge by measuring battery voltage minus surface charge. The open circuit voltage test is used primarily on nonserviceable batteries which allow no access to the liquid within.

H. Specific gravity--A measure of the density of a liquid compared to the density of water. Specific gravity is measured by a hydrometer and can be used to determine a battery's state of charge.

I. Surface charge--A charge contained on the surface of the battery grids. Surface charge is not indicative of the battery's true state of charge and can provide an erroneous voltage reading.

J. Sulfation--A chemical process that increases internal battery resistance.

K. Three-minute charge test--A test performed on serviceable batteries that have failed the load test. The three-minute charge test measures sulfation within a battery as well as measuring the battery's ability to recover charge.

L. Volts-amps tester (VAT)--A tester that combines volt-amp gauges, a carbon pile, and sufficient leads to conduct a variety of starter, charging, and battery system tests. The volts-amps tester is also called a BST tester.

II. Battery condition test equipment and procedures

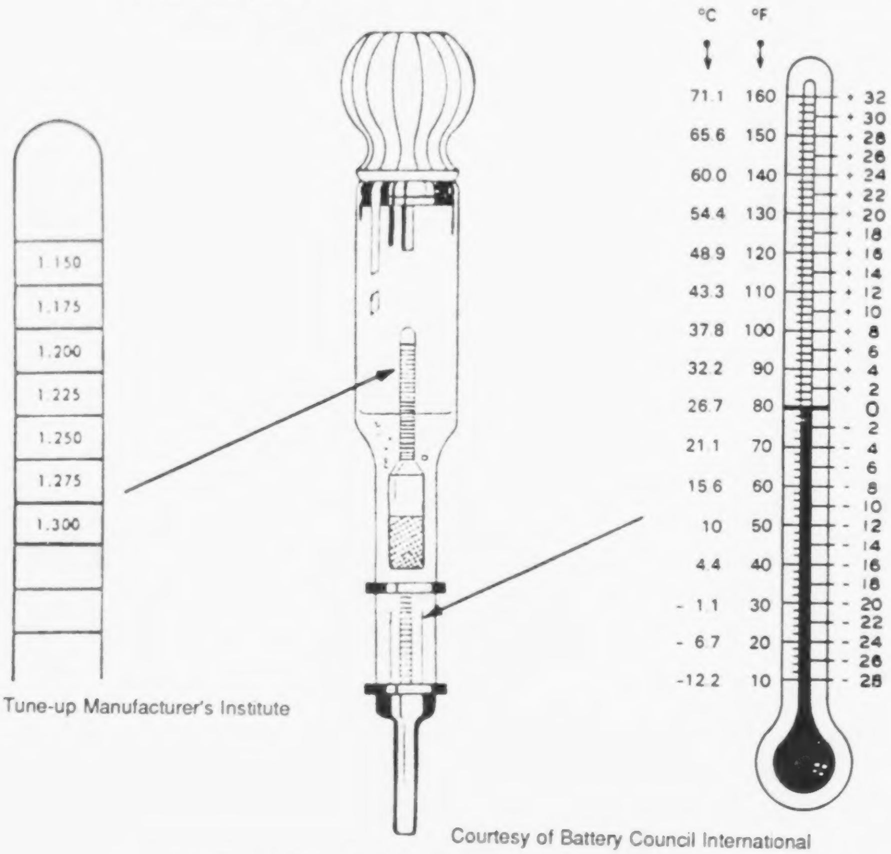
A. Hydrometer test

1. Hydrometers are used to perform state-of-charge tests on serviceable batteries.

a. The hydrometer measures the density of electrolyte within a battery. The hydrometer then compares the density of the electrolyte to that of water (which has a density of "1").

b. When the battery is charged, its ability to produce current (by way of chemical reaction) is restored.

c. The hydrometer has a glass float that is calibrated in thousandths of an inch. When the density of the electrolyte increases as a result of a greater state of charge in the battery, the float will rise higher in the hydrometer chamber. (The higher the float rises, the greater the density of the electrolyte.) The density of the electrolyte indicates its specific gravity.

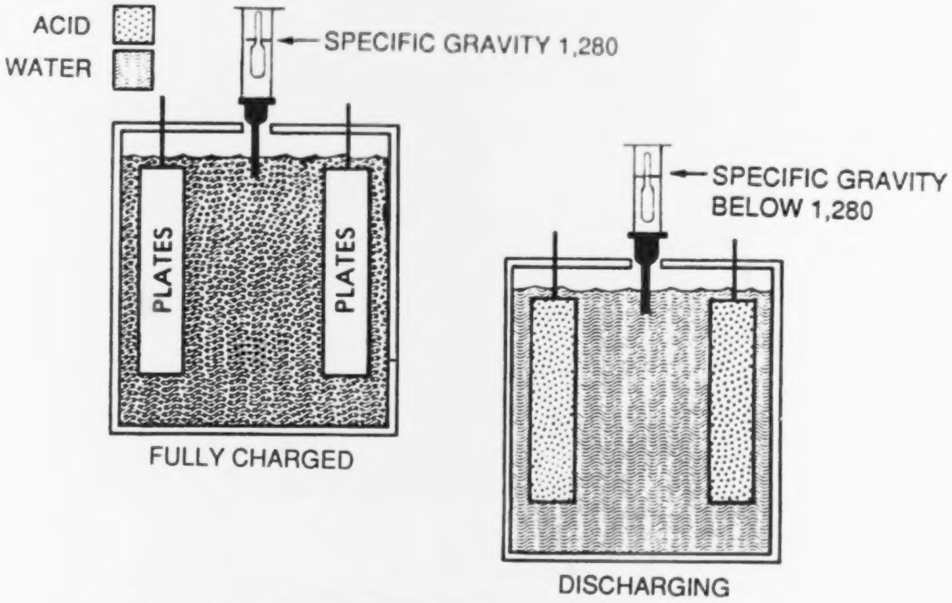

1.150
1.175
1.200
1.225
1.250
1.275
1.300
°C
°F
71.1 160 + 32
+ 30
65.6 150 + 28
+ 26
60.0 140 + 24
+ 22
54.4 130 + 20
+ 18
48.9 120 + 16
+ 14
43.3 110 + 12
+ 10
37.8 100 + 8
+ 6
32.2 90 + 4
+ 2
26.7 80 0
- 2
21.1 70 - 4
- 6
15.6 60 - 8
- 10
10 50 - 12
- 14
4.4 40 - 16
- 18
- 1.1 30 - 20
- 22
- 6.7 20 - 24
- 26
-12.2 10 - 28

Courtesy of Tune-up Manufacturer's Institute

Courtesy of Battery Council International

TEMPERATURE CORRECTED HYDROMETER

d. By sampling the acid from each cell, a comparison can be made between the density of the cells being tested and the density of cells from another battery that is known to be at full charge.



Courtesy of Tune-up Manufacturer's Institute

e. Hydrometers must be temperature compensated because the temperature of the electrolyte directly affects its density and specific gravity.

f. Because of its high acid content, electrolyte in a fully charged battery will have a specific gravity of 1.280. As the battery discharges, acid leaves the electrolyte and collects on the plates, causing the specific gravity of the electrolyte to drop.

2. Procedure for hydrometer test

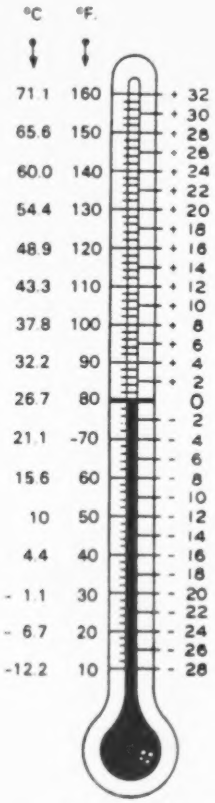
   a. Remove battery cell caps and make sure the cells contain a sufficient amount of electrolyte.

   b. Draw an electrolyte sample from cell #1. (Draw enough electrolyte to make the calibrated scale float but not enough to fill the hydrometer.)

   c. Holding the hydrometer vertically, read the number that is level with electrolyte surface. Record reading and return sample to cell #1.

   d. Draw an electrolyte sample from the remaining cells and repeat the above procedure.

e. Read the hydrometer's thermometer and compensate for error with the scale provided.


°C
°F.
71.1
65.6
60.0
54.4
48.9
43.3
37.8
32.2
26.7
21.1
15.6
10
4.4
- 1.1
- 6.7
-12.2
160
150
140
130
120
110
100
90
80
-70
60
50
40
30
20
10
+ 32
+ 30
+ 28
+ 26
+ 24
+ 22
+ 20
+ 18
+ 16
+ 14
+ 12
+ 10
+ 8
+ 6
+ 4
+ 2
0
- 2
- 4
- 6
- 8
- 10
- 12
- 14
- 16
- 18
- 20
- 22
- 24
- 26
- 28

Courtesy of Battery Council International

f. Below are two examples of using the thermometer to compensate for error in the specific gravity reading.

EXAMPLE NO. 1

Temperature below 80 F. (26.7 C)

Hydrometer Reading 1.250
Acid Temperature 20 F (-6.7 C)
Subtract .024 specific gravity
Corrected specific gravity is 1.226

EXAMPLE NO.2

Temperature above 80 F. (26.7 C)

Hydrometer Reading 1.235
Acid Temperature 100 F (37.8 c)
Add .008 specific gravity
Corrected specific gravity is 1.243

g. Compare readings. If the specific gravity of the electrolyte in any or all cells falls below 1.225, the battery has only a 75% charge. The battery cannot undergo further testing until it is charged. If the specific gravity of any two cells differs by more than .025, the battery is considered faulty and must be replaced.

BATTERY STATE OF CHARGE	SPECIFIC GRAVITY OF ELECTROLYTE IN COLD AND TEMPERATE CLIMATES	SPECIFIC GRAVITY OF ELECTROLYTE IN TROPICAL CLIMATES
Fully Charged	1.265	1.225
75% Charged	1.225	1.185
50% Charged	1.190	1.150
15% Charged	1.155	1.115
Discharged	1.120	1.080

Courtesy of Battery Council International

B. Open-circuit voltage test

1. The solution within a nonserviceable battery is inaccessible and cannot be tested with a hydrometer. However, a battery's voltage level is related to its state of charge; therefore, an open-circuit voltage test can determine the state of charge of a nonserviceable battery.

2. Equipment needed for the open circuit voltage test

   a. A voltmeter (for measuring battery voltage)

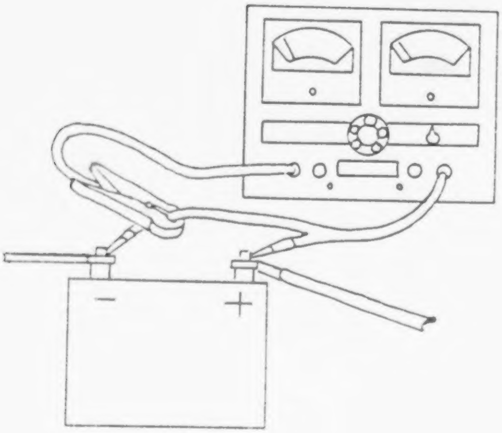
   b. An ammeter (for measuring the amount of charge removed from the battery during the voltage test)

   c. A carbon-pile (for producing a variable load during the test)

   (NOTE: A VAT [BST] tester [a single instrument consisting of a carbon pile, ammeter, and voltmeter] may be substituted for the above equipment.)

3. Procedure for open-circuit voltage test

   a. A recently charged battery will have a significant surface charge, which must be removed before a circuit voltage test is performed. Using a carbon pile, place a 20-amp drain on the battery for one minute.



b. Immediately following the 20-ampere drain, measure battery voltage.

c. A fully charged battery will test at 12.6 volts. Each .2 volt drop from 12.6 indicates a 25% decrease in the battery's state of charge.

TYPICAL OPEN-CIRCUIT VOLTAGE AND SPECIFIC VALUES

CHARGE LEVEL	SPECIFIC GRAVITY	VOLTAGE (12)	VOLTAGE (6)
100%	1.265	12.7	6.3
75%	1.225	12.4	6.2
50%	1.190	12.2	6.1
25%	1.155	12.0	6.0
DISCHARGED	1.120	11.9	6.0

Courtesy of Battery Council International

d. Any battery below 75% charge should be recharged before undergoing further testing.

C. Battery load test

1. A load test can determine the ability of the battery to deliver high current during peak demands. The battery is tested by a load device; its current delivery is measured against decreasing voltage and compared to the required capacity.

2. Equipment needed for the battery load test.

   a. A voltmeter (for measuring the battery voltage during the load test)

b. An ammeter (for measuring the amount of charge removed from the battery during the load test)

(NOTE: The ammeter used in the load test must have a 500-amp range.)

c. A carbon-pile (acts as a variable load during the test)

(NOTE: A VAT [BST] tester [a single instrument consisting of a carbon pile, ammeter, and voltmeter] may be substituted for the above equipment.)

3. Procedure for preliminary battery load test

a. Perform a hydrometer test or open-circuit voltage test to establish the battery's state of charge (procedures for both tests are described above).

(NOTE: Do not perform a load test unless the battery is at a 75% charge or greater.)

b. Determine either the battery's amp hours or cold-cranking amps to establish the battery's capacity requirement.

Amp Hour Rating

Amp Hour Rating x 3 = load test amps

Cold-cranking amps ÷ 2 = load test amps

Reserve capacity x 2 = load test amps

Watts x 12 = load test amps

Cubic inches x 2 = load test amps

(NOTE: Either the amp hours or cold-cranking amps should be noted on the battery's identification tag.)

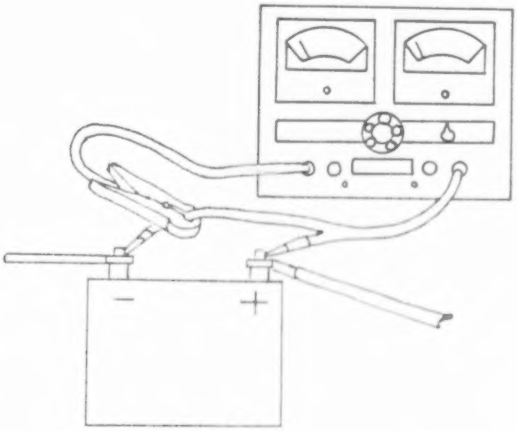
c. Compare the battery's cold-cranking amps to the cubic-inch displacement of the vehicle's engine. In vehicles with gasoline engines, cold-cranking amps should be about double the cubic inches of engine displacement. Diesel engines have higher cylinder compression and require about four cold cranking amps per cubic inch of engine displacement.

d. If the cold-cranking amp rating is too small when compared to the cubic-inch displacement of the engine, test the battery according to the cold-cranking amps rating found on the battery. If the cold-cranking amps are higher than the engine's cubic-inch displacement, test the battery according to the engine's cubic-inch displacement.

e. Establish load test specifications. Under a load, a 12-volt battery should be able to deliver the specified amount of current for 15 seconds without falling below 9.6 volts. (A 6-volt battery should not fall below 4.8 volts.)

4. Battery load test procedures

a. After performing all preliminary load test procedures, attach a carbon pile lead (VAT test leads) to the positive or negative terminals of the battery. Be sure that the load test knob is turned off.



b. Clamp the VAT 40 inductive pick up around the negative cable of the tester. If using individual pieces of test equipment, attach the ammeter leads in series to the carbon pile and the battery. Connect other tester leads to the positive or negative terminals of the battery.

c. Attach voltmeter leads in parallel to battery (internal on VAT tester).

d. Create a load on the battery by twisting the carbon pile control knob. Volt readings should stay above 9.6 for 12-volt batteries or 4.8 volts for 6-volt batteries. Try to maintain the amp flow at load-test specifications for 15 seconds.

D. Three-minute charge test

(CAUTION: Never perform a three-minute charge test on any type of sealed battery.)

1. A battery is either bad or inadequately charged if it registers below 9.6 volts during the load-capacity test. The three-minute charge test is only performed on batteries that have failed the load-capacity test.

2. Equipment needed for the three-minute charge test

a. Battery charger (for producing a 40-amp charging rate for three minutes)

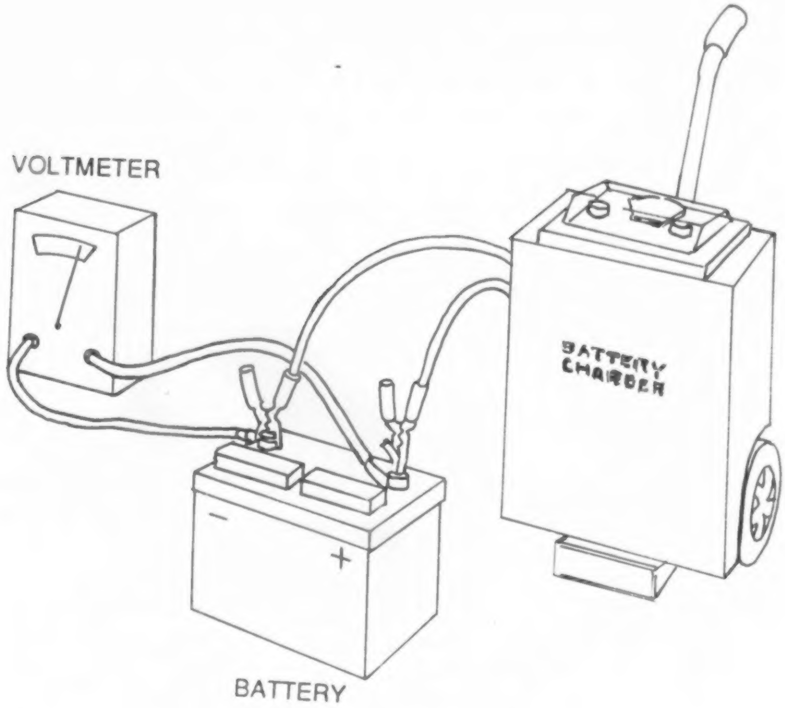
b. Voltmeter (for measuring an increase in battery voltage during charging)

c. VAT tester (for repeating the battery load test after three-minute charge)

3. Procedure for three-minute charge test

a. Charge battery at about a 40-amp rate and observe voltmeter readings.

b. If voltmeter readings stay below 15.5 volts, charge battery for three minutes. Immediately after the three-minute charge, perform a load-capacity test on the battery.



c. If the battery fails the load-capacity test, it should be replaced. If the battery passes, it is good and, therefore, must undergo an additional charging test.

d. If voltmeter readings exceed 15.5 volts during the three-minute charge, the battery is probably sulfated and should be replaced.

E. Procedure for battery external current drain test

1. Faulty vehicle circuits can draw small amounts of current from a battery, causing the battery to discharge very slowly. The maximum acceptable current drain on a battery is .5 amperes. Unwanted current drain is often very small and can be detected only with special equipment and procedures. Unwanted current drain can sometimes be located with an ohmmeter. Sometimes the drain can be detected only when 12 volts is applied to the circuit.

2. Equipment needed for this test

    a. An ohmmeter (for finding current paths with a resistance of less than 24 ohms)

    b. A small-scale ammeter (for measuring current draw)

    (NOTE: The ammeter hooks in series between the battery negative post and the electrical system's ground circuit.)

    (NOTE: A current multiplier [a wire loop for multiplying the small current drain so that a larger ammeter can read it at a x 10 scale] and VAT tester can be substituted for the above equipment.)

3. Procedure for detecting battery external current drain (using an ohmmeter)

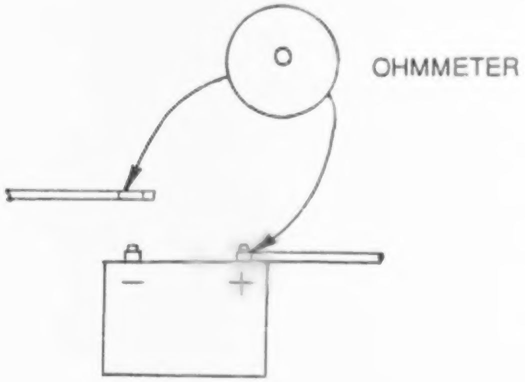
    a. Turn off all of the vehicle's electrical systems (close doors and remove the bulb in the hood light).

    b. Disconnect the negative and positive battery cables.

    c. Select lowest ohmmeter range. Ohmmeter should read less than 24 ohms.

    d. Connect one of the ohmmeter's leads to the battery's positive cable and the other lead to the negative cable.

    (**CAUTION**: Never connect an ohmmeter to a battery.)

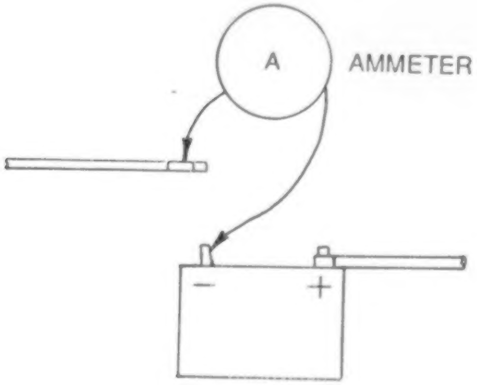


e. An ohmmeter reading of more than 24 ohms indicates a current drain problem. Begin disconnecting individual circuits. If the ohmmeter reading drops below 24 ohms when an individual circuit is disconnected, that circuit is responsible for the current drain.

4. Procedure for detecting battery external current drain (using a small scale ammeter)

a. Turn off all systems.

b. Disconnect negative battery cable and place ammeter in series between negative cable and negative post.



c. An ammeter reading of more than .5 amps indicates a current drain problem. Begin disconnecting individual circuits. If the ammeter reading drops below .5 amps when an individual circuit is disconnected, that circuit is responsible for the current drain.

5. Procedure for detecting battery external current drain (using current multiplier [wire loop] and VAT tester)

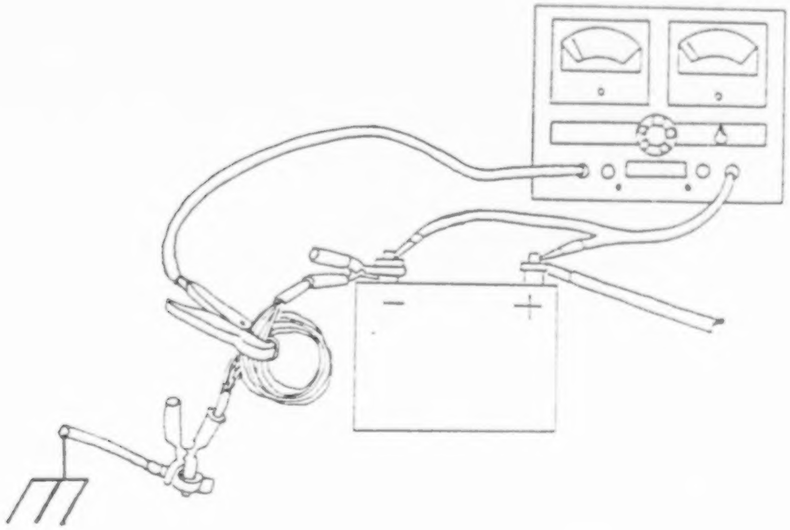
a. Wrap exactly 10 feet of 16-gauge wire into a 4-inch coil. Secure wire with tape so that it forms a loop.

b. Disconnect negative cable. Place loop in series between negative cable and battery post. Clamp inductive pickup from VAT around the loop. Clamp the positive and negative leads to the battery. Observe polarity.

c. Turn off all systems.

d. Read ammeter from low scale of VAT tester. (This reading is ten-times greater than the actual reading. One amp would register as 10 amperes on the meter dial.)

e. An ammeter reading of more than .5 amps indicates a current drain problem. Begin disconnecting individual circuits. If the ammeter reading drops below .5 amps when an individual circuit is disconnected, that circuit is responsible for the current drain.



F. Determining a battery's state of charge, load capacity, and current drain can give the technician a good idea of the battery's ability to perform under normal circumstances.

MODULE: ELECTRICAL SYSTEMS

CHECKING AN AUTOMOTIVE BATTERY FOR SURFACE LEAKAGE

Equipment:

Voltmeter
Serviceable battery
Safety glasses

Procedure:

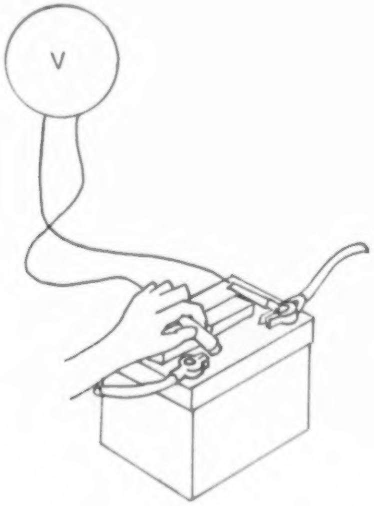
Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Using the procedure outlined below, measure the amount of current leakage between the battery posts. ___ ___ ___ ___

   a. Set the voltmeter to the 16-volt scale.

   b. Connect the negative lead of the voltmeter to the negative battery post.



   c. Move the positive lead of the voltmeter between the posts on the battery.

d. If the reading is above 5 volts, the battery should be cleaned. For this procedure refer to JS2-L2-UIV. Record observations.

Next to negative post ___ volts

Halfway between post ___ volts

Next to positive post ___ volts

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency E2. Final evaluation for E2 will be made at the end of JS5-L2-UIV.)

JS2-L2-UIV

MODULE: ELECTRICAL SYSTEMS

CLEANING THE CASE AND TERMINALS OF AN AUTOMOTIVE BATTERY

Equipment:

Battery pliers
Battery terminal remover
Battery terminal and post cleaner
Terminal expander
Battery lifting tool
Baking soda
Common hand tools
Soft brush
Serviceable battery
Safety glasses

Procedure:	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2. Following the procedure outlined below, clean the battery case and terminals. Be sure to use the proper equipment.	__ __ __ __

a. Remove battery cables.

(**CAUTION:** Always remove negative battery cable first.)

b. Use battery lifting tool to remove battery from vehicle.

c. Move battery to an area designated for battery cleaning.

d. Mix a paste of baking soda and water, then, brush the paste on the top of the battery.

e. After acid has neutralized, thoroughly wash the battery top with a liberal amount of water.

(**CAUTION:** Do not allow the cleaning solution to come into contact with skin or clothing. Do not allow it to get inside a serviceable battery.)

3. Following the procedure outlined below, clean the battery post and cable terminals.	__ __ __ __

a. Clean the post and cable terminals with a battery terminal post cleaner.

b. True the eye of the terminal with a terminal expander [illegible]

c. Replace the bolt and nut if they are corroded or worn-out.

4. If the cable is excessively corroded or if the insulation is damaged, replace the entire cable using the procedure outlined below. — — — —

    a. Remove the negative battery terminal.

    b. Remove the old cable.

    c. Route the new cable through hangers or clamps.

    d. Properly connect the end of the cable opposite the battery.

    e. Connect the terminal at the battery end.

    f. Connect the negative battery terminal.

Average of above evaluations* — — — —

(*This average is the final evaluation for Competency E1.)

MODULE: ELECTRICAL SYSTEMS

MEASURING STATE OF CHARGE OF AN AUTOMOTIVE BATTERY

Equipment:

Hydrometer
Voltmeter
Cell Probes
VAT
Serviceable battery
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Listed below are four methods of measuring a battery's state of charge. Put a check beside the method tht the instructor has assigned. Items 3 through 6 on this job sheet outline these procedures. To measure battery state of charge, find the numbered item that covers the assigned procedure and follow it carefully.

   _____ Hydrometer test (3)

   _____ Open circuit test (4)

   _____ Individual cell test (5)

   _____ Individual cell test under load ()

   (NOTE: The instructor may assign an or all of the above procedures.)

3. Following the procedure outlined elow, perform a hydrometer test on a battery. ___ ___ ___ ___

   a. Check the specific gravity ! the cells by inserting the tip of the hydrometer into the cell.

   b. Draw a sample of electrolyte.

   c. Use the lines on the float to rei the fluid level.

   d. Record observations on chart low.

   (NOTE: Consider temperaure factor when recording reading. Remember that the readin will not be correct if water has just been added to the battery.)

	CELL NUMBER					
Specific gravity reading	1	2	3	4	5	6
Electrolyte temperature						
Corrected gravity reading						
Gravity range (total + - variation)						

EVALUATION

*If all readings are even at 1.215 or above, battery is OK.

*If all readings are even but less than 1.215, recharge and retest.

*If the high-low variation between cells is less than 30 points, recharge and retest.

*If the high-low variation between cells exceeds 50 points, replace the battery and run additional tests.

(*Bring battery to full charge condition.)

According to this test, the battery is:

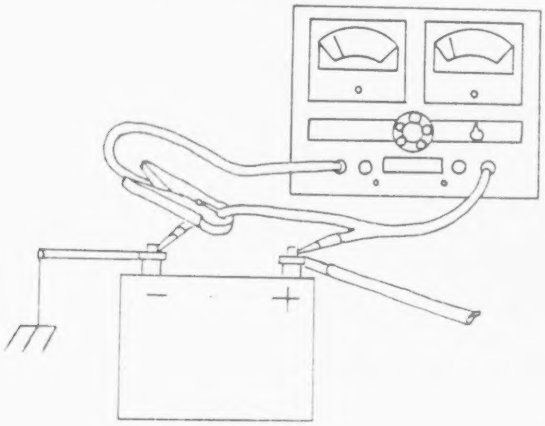
____good

____fair

____ bad

4. Following the procedure outlined below, perform an open-circuit voltage test on a battery. — — — —

a. Using a VAT, place a 20-amp drain on the battery for 1 minute.



b. Turn off load knob.

c. Immediately read the voltmeter and record observations.

d. According to this test, the battery is:

___ good

___ fair

___ bad

5. Following the procedure outlined below, perform an individual cell test.

a. Attach the cell probes to the small voltmeter leads.

b. Set voltmeter to the 0 to 4 range.

c. Remove filler-vent caps from battery.

(NOTE: The testing procedure will indicate the battery cells by number; the cell at the same end as the battery's positive terminal is cell #1.)

(NOTE: The below procedure is for a 12-volt battery. For a 6-volt battery, follow steps d, e, i, j, k.)

d. Place the positive probe on the positive terminal post and negative probe in cell #1. Record exact reading.

e. Place positive probe in cell #1 and negative probe in cell #2. Record exact reading on chart below.

f. Place positive probe in cell #2 and negative probe in cell #3. Record exact reading on chart below.

g. Place positive probe in cell #3 and negative probe in cell #4. Record exact reading on chart below.

h. Place positive probe in cell #4 and negative probe in cell #5. Record exact reading on chart below.

i. Place positive probe in cell #5 and negative probe in cell #6. Record exact reading on chart below.

j. Place positive probe in cell #6 (or #3 in a 6-volt battery) and negative probe on negative terminal post. The voltmeter should read .1 to .2 volts to the left of zero . Add this reading to the one obtained in step 1. Now all six cell readings should be within .1 volts.

k. The variation is obtained by subtracting each of the cell readings from the highest reading. Record results on chart below.

Step	Test	Reading	Variation
d	Positive terminal to cell 1		
e	Cell 1 to cell 2		
f	Cell 2 to cell 3		
g	Cell 3 to cell 4		
h	Cell 4 to cell 5		
i	Cell 5 to cell 6		
j	Cell 6 to negative terminal		
Reading step d plus j			

(NOTE: Readings should have no more than a .1 volt variation.)

l. According to this test the battery is:

___ good

___ fair

___ bad

6. Following the procedure outlined below, test an individual battery cell under a load. ____

a. Attach the cell probes to the small voltmeter leads.

b. Connect large VAT leads to battery and the inductive amp probe around the negative VAT lead. Be sure to observe polarity.

c. Set voltmeter to the 0 through 4 range.

d. Remove filler-vent caps from battery.

(NOTE: The testing procedure will indicate the cells by number; the cell at the positive terminal end of the battery is cell #1.)

(NOTE: The below procedure is for a 12-volt battery. For a 6-volt battery, follow steps d, e, i, j and l.)

e. Turn the load control knob clockwise until a load of 50 amps is placed upon the battery.

f. Place positive probe on positive terminal post and negative probe in cell #1. Record exact reading on chart below.

g. Place positive probe in cell #1 and negative probe in cell #2. Record exact reading on chart below.

h. Place positive probe in cell #2 and negative probe in cell #3. Record exact reading on chart below.

i. Place positive probe in cell #3 and negative probe in cell #4. Record exact reading on chart below.

j. Place positive probe in cell #4 and negative probe in cell #5. Record exact reading on chart below.

k. Place positive probe in cell #5 and negative probe in cell #6. Record the exact reading on chart below.

l. Place positive probe in cell #6 (or #3 in a 6-volt battery) and negative probe on negative terminal post. The voltmeter should read to the left of zero .1 to .3 volts. On the chart below, add this reading to the one obtained in step 1. Now all six cell readings should be within .2 volts.

m. Turn the load control off (by turning it counterclockwise).

n. The variation is obtained by subtracting each cell reading from the highest reading. Complete the chart below.

Step	Test	Reading Variation
f	Positive terminal to cell 1	
g	Cell 1 to cell 2	
h	Cell 2 to cell 3	
i	Cell 3 to cell 4	
j	Cell 4 to cell 5	
k	Cell 5 to cell 6	
l	Cell 6 to negative terminal	
	Reading step d plus j	

(NOTE: Readings should have no more than .1 volt variation)

o. According to this test, the battery is:

___ good

___ fair

___ bad

Average of above evaluations* — — — —

(*This average can include any or all of the evaluations for items 3 through 6. This average is a partial evaluation for Competency E2. Final evaluation for E2 will be made at the end of JS5-L2-UIV.)

MODULE: ELECTRICAL SYSTEMS

LOAD TESTING AN AUTOMOTIVE BATTERY

Equipment:

VAT
Serviceable battery
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Calculate the load test amperage. __ __ __ __

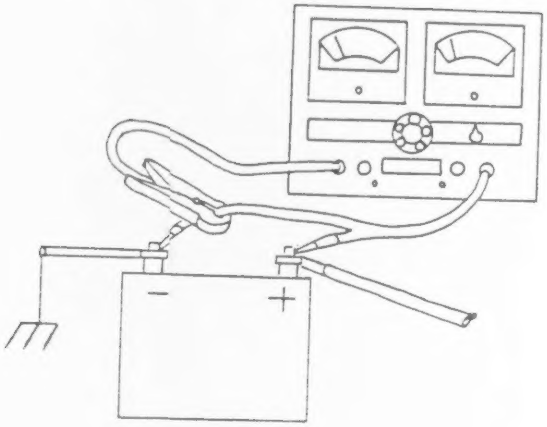
   Amp hour rating x 3 = load test amps
   Cold cranking amps ÷ 2 = load test amps
   Reserve capacity x 2 = load test amps
   Watts x 12 = load test amps
   Cubic inch x 2 = load test amps

   Record load test amps_____

3. Following the procedure outlined below, perform a load test on a serviceable battery. __ __ __ __

   a. Establish battery state of charge. (Refer to JS3-L2-UIV for this procedure.) If state of charge is less than 75%, charge the battery before proceeding further.

   b. Attach VAT leads according to the following illustration (or follow the instructions on the tester).



c. Using the load test knob, oad the battery until it reaches the desired load test amperage.

d. After the battery has been at the desired load test amperage for 15 seconds, read the voltage and tırn off load test knob.

e. Record observations

Amps start ____

Amps end ____

Volts end ____

f. According to this test, the batter is:

___ good

___ fair

___ bad

Average of above evaluations* — — — —

(*This average is a partial eluation for Competency E2. Final evaluation for E2 will be made at the end of JS5-LUIV.)

JS5-L2-UIV

MODULE: ELECTRICAL SYSTEMS

PERFORMING A THREE-MINUTE CHARGE TEST ON AN AUTOMOTIVE BATTERY

Equipment:

Voltmeter
Battery charger
Serviceable battery
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, perform a three-minute charge test. ___ ___ ___ ___

   (**CAUTION:** Never perform a three-minute charge test on any type of sealed battery.)

   a. Connect the voltmeter and battery charger to the battery. Be sure to observe battery polarity.

   b. Set the battery charger to the correct voltage and start charging at a rate as close to 40 amps as possible without exceeding 40 amps.

   c. Time the process for 3 minutes and determine the condition of the battery while the charger is still operating.

d. Battery is good if total voltage remains under 15.5 volts during the test. Battery is bad if total voltage goes above 15.5 volts.

e. According to this test, the battery is:

___ good

___ fair

___ bad

(NOTE: For a 6 V.H. battery 7.75 volts is the cut-off voltage. Charge at a rate of 75 amps.)

d. Battery is good if total voltage remains under 15.5 volts during the test. Battery is bad if total voltage goes above 15.5 volts.

e. According to this test, the battery is:

___ good

___ fair

___ bad

(NOTE: For a 6 V.H. battery 7.75 volts is the cut-off voltage. Charge at a rate of 75 amps.)

Average of above evaluations* ____

(*This average is a partial evaluation for Competency E2. Final evaluation for E2 will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency E2 by averaging the final evaluations from JS1-L2-UIV, JS3-L2-UIV, JS4-L2-UIV, and JS5-L2-UIV. Use the spaces provided below.

	Evaluation 3	 2	 1	 N
JS1-L2-UIV	___	___	___	___
JS3-L2-UIV	___	___	___	___
JS4-L2-UIV	___	___	___	___
JS5-L2-UIV	___	___	___	___
Final evaluation for Competency E2	___	___	___	___

JS6-L2-UIV

MODULE: ELECTRICAL SYSTEMS

CHECKING FOR EXTERNAL DRAINS ON AN AUTOMOTIVE BATTERY

Equipment:

Ohmmeter
Ammeter (low range)
VAT
Wire loop
Selected vehicle
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Listed below are three methods of checking for external current drain on an automotive battery. Put a check beside the method assigned by the instructor. Items 3 through 5 on this job sheet outline these procedures. To measure external current drain, follow the procedures in the items assigned by the instructor. __ __ __ __

   _____ Check for external current drains using an ohmmeter. (3)

   _____ Check for external current drains using a low-range ammeter. (4)

   _____ Check for external current drain using a wire loop and a VAT. (5)

   (NOTE: The instructor may assign any or all of the above procedures.)

3. Using an ohmmeter, check for external current drain on a battery. Follow the procedure outlined below. __ __ __ __

   a. Set up ohmmeter for resistance test. Calibrate ohmmeter to the lowest scale.

   b. Turn off as many of the vehicle's circuits as possible.

   c. Disconnect the negative battery terminal and then the positive battery terminal.

      (**CAUTION:** Always disconnect the negative battery cable first.)

   d. Connect one ohmmeter lead to the positive battery terminal (cable) and connect the other ohmmeter lead to the negative battery terminal (cable).

   e. Measure circuit resistance. Resistance should be less than 24 ohms. If greater than 24 ohms, locate source of drain and recommend repairs. Record observations.

4. Using a low-range ammeter, check for external current drain on a battery. Follow the procedure outlined below. ____

   a. Set ammeter to lowest range.

   b. Turn off as many of the vehicle's circuits as possible.

   c. Disconnect negative battery terminal.

   d. Connect the negative ammeter lead to the negative post of the battery.

   e. Connect the positive ammeter lead to the negative battery terminal (cable).

   f. Measure current flow. It should be less than .5 amps. If it is greater than .5 amps, locate source of drain and recommend repairs. Record observations.

5. Using a wire loop and VAT, check for external current drains. Follow the procedure outlined below. ____

   a. Construct a wire loop if one is not already available.

   b. Turn off as many of the vehicle's circuits as possible.

   c. Disconnect negative battery terminal.

   d. Connect wire loop in series between the negative post and the negative battery cable.

   e. Adjust VAT to lowest range on ammeter.

   f. Connect VAT as illustrated below.

   g. Measure current flow. It should be less than .5 amps. Remember that 5 amps on scale equals .5 amps of current flow. If current flow is greater than .5 amps, locate source of drain and recommend repairs. Record observations.

Average of above evaluations* ____

(*This average can include any or all of the evaluations of items 3 through 5 in this job sheet. This average is a partial evaluation for Competency D2. Final evaluation for D2 will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency D2 by averaging the final evaluations from JS5-L3-UIII, JS7-L3-UIII, JS11-L3-UIII, and JS6-L2-UIV. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS5-L3-UIII	___	___	___	___
JS7-L3-UIII	___	___	___	___
JS11-L3-UIII	___	___	___	___
JS6-L2-UIV	___	___	___	___
Final evaluation for Competency D2	___	___	___	___

MODULE: ELECTRICAL SYSTEMS

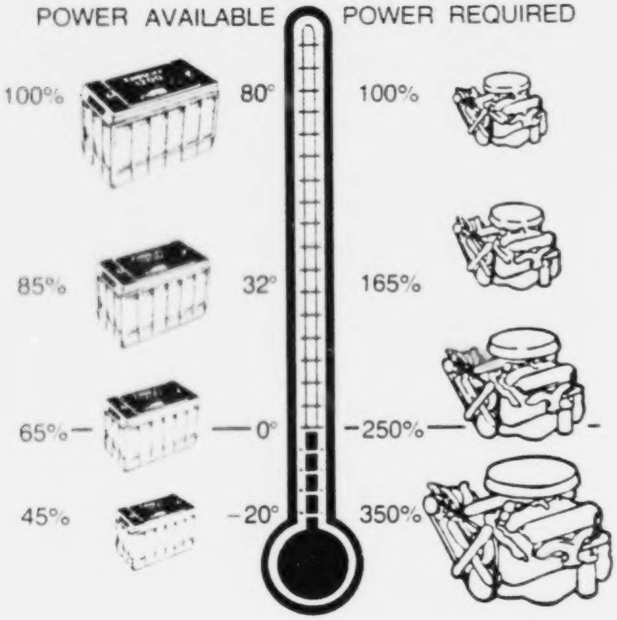
UNIT IV: BATTERY DIAGNOSIS AND SERVICE

LESSON 3: CHARGING AND INSTALLING A BATTERY AND JUMP STARTING A VEHICLE

I. Classifying batteries

- A. Types of battery ratings
    - 1. The amp hour rating indicates the length of time that a fully charged battery can deliver a specific quantity of charge (current) at 80 F (26.7 C).
    - 2. The cold cranking amps rating indicates the number of amps that a battery can deliver for thirty seconds at 0 F (-17.8 C) without cell voltage falling below 1.2 volts per cell. (Cell voltage should not fall below 1.2 volts per cell in 12-volt batteries.) The cold cranking amps rating is obviously a good indication of the battery's ability to perform in cold weather.
    - 3. The reserve capacity rating indicates the length of time that a battery can deliver 25 amps at an acceptable voltage level. Reserve capacity is measured in minutes and is used to indicate how long the battery could provide minimum current if the charging system failed.
- B. Batteries are sized by case dimensions. Case dimensions are standardized by group.

    (NOTE: Some groups are interchangeable but others are not; therefore, be sure that the new battery will fit into the battery box.)
- C. Types of battery terminals and their locations
    - 1. Top post terminals are arranged either side by side or diagonally. While the side-by-side terminal arrangement has no special designation, the diagonal will have an "F" after the group number.
    - 2. In batteries with side post terminals, bolts secure cables to terminals which are molded into the side of the battery case.
    - 3. Battery capacity
        - a. An engine requires about 1 amp of current for each cubic inch of displacement. When selecting a battery, make sure the minimum cold-cranking amps is equal to the cubic- inch displacement of the engine with which the battery will be used. Remember that low temperatures will increase the need for engine cranking power while decreasing battery power.


POWER AVAILABLE
POWER REQUIRED
100%
80°
100%
85%
32°
165%
65%
0°
250%
45%
-20°
350%

Courtesy of Delco Remy Division

b. Match battery voltage to vehicle (usually 12 volts).

c. It is not necessary to match reserve capacity minutes rating to that of the vehicle's original battery.

II. Charging a battery

A. Serviceable dry-charged batteries must be filled with electrolyte and charged before installation. The rate of charge is determined by the amp rating of the battery.

(**CAUTION:** Charging rates that exceed 15 volts can damage the battery and should be avoided. On a sealed battery, the maximum charge rate is 40 amps. Never charge a frozen battery.)

BATTERY CHARGING GUIDE
(6-Volt and 12-Volt Batteries)
Recommended Rate* and Time for Fully Discharged Condition

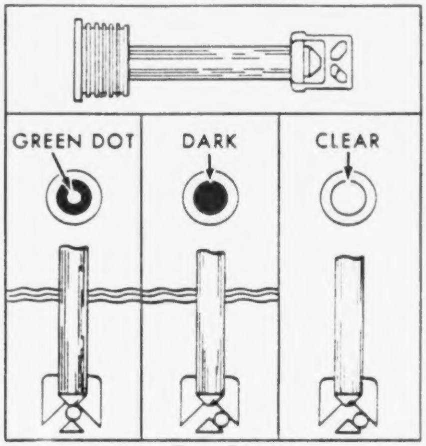
Reserve Capacity Rating	Twenty Hour Rating	5 Amperes	10 Amperes	20 Amperes	30 Amperes	40 Amperes
75 Minutes or less	50 Ampere-Hours or less	10 Hours	5 Hours	2 1/2 Hours	2 Hours	
Above 75 To 115 Minutes	Above 50 To 75 Ampere-Hours	15 Hours	7 1/2 Hours	3 1/4 Hours	2 1/2 Hours	2 Hours
Above 115 To 160 Minutes	Above 75 To 100 Ampere-Hours	20 Hours	10 Hours	5 Hours	3 Hours	2 1/2 Hours
Above 160 To 245 Minutes	Above 100 To 150 Ampere-Hours	20 Hours	15 Hours	7 1/2 Hours	5 Hours	3 1/2 Hours
Above 245 Minutes	Above 150 Ampere-Hours		20 Hours	10 Hours	6 1/2 Hours	5 Hours

Courtesy of Delco Remy Division

(**CAUTION:** On batteries that have a state-of-charge indicator and a load test value of less than 200 amps, the green dot should be visible after 50 ampere-hours of charge. On batteries that have a state-of-charge indicator and a load test value of greater than 200 amps, the green dot should be visible after 75 ampere-hours of charge. In the event that the green state-of-charge indicator does not appear after the proper amount of time has elapsed, continue to charge the battery for another 50 to 75 ampere-hours. If the green state-of charge indicator still does not appear, replace the battery.)

B. On a nonserviceable battery, the charging voltage should also be limited to a maximum of 15-volts. The above rate table should also be used to determine the rate of charge of a nonserviceable battery.

C. A state-of-charge indicator can be found on some nonserviceable batteries. The state of charge indicator is green when charged above 65% and dark when charged below 65%. If the charge indicator is clear, the battery is low on electrolyte and should be replaced.



Courtesy of Delco Remy Division

III. Procedures for installing a battery

A. Disconnect the cables. Always remove the ground cable first and connect it last. Use a battery cable puller to remove the cables. Use a battery carrying strap or clamp to lift and transport battery.

(NOTE: The EPA considers discarded batteries to be hazardous waste. The technician should be aware of battery disposal regulations that apply in his or her area.)

B. Clean or replace cables or cable ends.

C. Bring new battery to a state of full charge.

D. Clean and repair battery box or platform and inspect hold-down devices.

IV. Jump starting a vehicle with a negative ground

A. Precautions

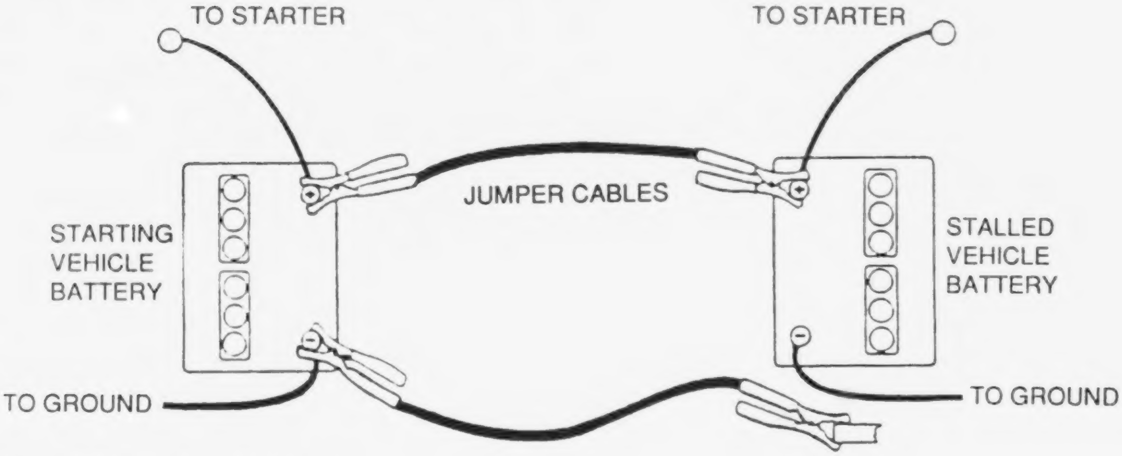
1. When exposed to an arc, battery outgassing can cause an explosion.

2. Never attempt to jump a car with a frozen battery. The rapid expansion of the grid by the donor battery can split the frozen battery.

3. Jumping a dead battery can cause great current surging. Such surging can damage delicate electronic components in computers and charging systems. Always run the donor vehicle while jumping to regulate voltage and current surging.

B. Procedure for jump starting

1. Inspect dead battery for cracks and excessive corrosion on the cables and terminal ends. Make sure battery is not frozen. Clean cables and terminal ends thoroughly before proceeding.



Courtesy of Battery Council International

(CAUTION - MAKE CERTAIN VEHICLES DO NOT TOUCH.)

2. Connect the positive cable to the positive post of the donor and dead batteries. Wiggle cable to insure a good connection.

3. Connect one end of negative cable to the donor negative post.

4. Connect the other end of the negative cable to the engine block of the dead vehicle.

5. Start donor vehicle, and allow it to run for one or two minutes at high idle.

6. Crank dead vehicle for fifteen seconds. Let it rest for 30 seconds then crank it again for 15 seconds. Repeat procedure until the vehicle starts.

7. Disconnect the negative cable first and the positive last.

   (**CAUTION:** Multiple batteries are used in some vehicles. The jump start procedure is basically the same as for single-battery vehicles. Take care not to allow the donor vehicle to become overcharged by the multiple-battery charging system. Quickly disconnect donor vehicle after the dead vehicle starts.)

MODULE: ELECTRICAL SYSTEMS

AUTOMOTIVE BATTERY SERVICE

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. List the two basic ingredients of the paste commonly used to remove corrosion from a battery.

2. The water level in a battery should be how many inches below the top of the case?

3. How many amperes is the fast charging rate for a 12-volt battery?

4. The high-discharge load test should be done for more than 15 seconds at how many times the amp-hour rating?

5. Explain why the technician must compensate for temperature variation in the electrolyte when conducting a specific gravity test.

6. List three methods of rating batteries.

7. A battery that has a specific gravity reading of 1.225 at 80°F would be at what percentage of charge?

8. What is the name of the explosive gas given off by batteries?

9. List the two most common methods manufacturers use to identify the positive post.

MODULE: ELECTRICAL SYSTEMS

AUTOMOTIVE BATTERY SERVICE

(ANSWER SHEET)

1. Baking soda and water
2. 1/2 inch
3. 40 amperes
4. 3 times the amp-hour rating
5. The temperature of the electrolyte directly affects its density and specific gravity.
6. Cold-cranking amps, reserve capacity, and amp-hour rating
7. 75%
8. Hydrogen
9. Manufacturers put a positive mark (+) on the case and make the positive post larger.

MODULE: ELECTRICAL SYSTEMS

CHARGING AN AUTOMOTIVE BATTERY

Equipment:

Voltmeter
Battery charger
Serviceable battery
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___
2. Using one of the methods described in JS2-L3-UIV, determine the battery's state of charge. Record observations. ___ ___ ___ ___
3. Calculate the time and amp rate that will be required to recharge the battery completely. Use the following chart. ___ ___ ___ ___

BATTERY CHARGING GUIDE
(6-Volt and 12-Volt Batteries)
Recommended Rate* and Time for Fully Discharged Condition

Reserve Capacity Rating	Amp Hour Rating	5 Amperes	10 Amperes	20 Amperes	30 Amperes	40 Amperes
75 Minutes or less	50 Ampere-Hours or less	10 Hours	5 Hours	2 1/2 Hours	2 Hours	
Above 75 To 115 Minutes	Above 50 To 75 Ampere-Hour	15 Hours	7 1/2 Hours	3 1/4 Hours	2 1/2 Hours	2 Hours
Above 115 To 160 Minutes	Above 75 To 100 Ampere-Hours	20 Hours	10 Hours	5 Hours	3 Hours	2 1/2 Hours
Above 160 To 245 Minutes	Above 100 To 150 Ampere-Hours	30 Hours	15 Hours	7 1/2 Hours	5 Hours	3 1/2 Hours
Above 245 Minutes	Above 150 Ampere-Hours		20 Hours	10 Hours	6 1/2 Hours	5 Hours

*Initial rate for constant voltage taper rate charger

Courtesy of Delco Remy Division

(**CAUTION**: On batteries that have a state-of-charge indicator and a load test value of less than 200 amps, the green dot should be visible after 50 ampere-hours of charge. On batteries that have a state-of-charge indicator and a load test value of greater than 200 amps, the green dot should be visible after 75 ampere-hours of charge. In the event that the green state-of-charge indicator does not appear after the proper amount of time has elapsed, continue to charge the battery for another 50 to 75 ampere-hours. If the green state-of-charge indicator still does not appear, replace the battery.)

To avoid damage charging rate must be reduced or temporarily halted if:

1. Electrolyte temperature exceeds 125 F.
2. Violent gassing or spewing of electrolyte occurs.

Record Calculations

Amps _____ Time ____

3. Make sure electrolyte is at the proper level in all cells. If not refill. __ __ __ __

4. Following the procedure outlined below, recharge the battery. __ __ __ __

   a. Connect the voltmeter and the battery charger to the battery. Be sure to observe battery polarity.

   b. Turn off the battery charger, and adjust the charging rate to the desired level.

   (**CAUTION:** Do not exceed 15 volts when adjusting charging level. Do not allow gassing or the spewing of electrolyte).

   c. Charge battery for recommended time.

   (**CAUTION:** Do not overcharge the battery.)

Average of above evaluations* __ __ __ __

(*This is the final evaluation for Competency E4.)

MODULE: ELECTRICAL SYSTEMS

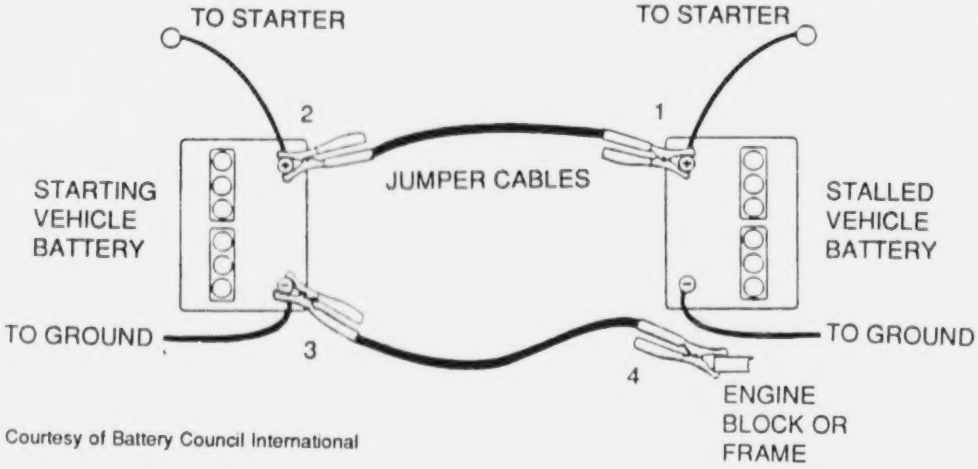
JUMP STARTING A VEHICLE

Equipment:

Jumper cables
Safety glasses

Procedure:	Evaluation 3	 2	 1	 N
1. Wear safety glasses while doing all procedures on this job sheet.	___	___	___	___
2. Following the procedure outlined below, jump start a vehicle that has a negative ground.	___	___	___	___

- a. Inspect the dead battery.
- b. Connect the jumper cables.


TO STARTER
TO STARTER
2
1
STARTING VEHICLE BATTERY
JUMPER CABLES
STALLED VEHICLE BATTERY
TO GROUND
3
TO GROUND
4
ENGINE BLOCK OR FRAME

Courtesy of Battery Council International

(CAUTION - MAKE CERTAIN VEHICLES DO NOT TOUCH.)

- c. Start the engine in the donor vehicle and run it for 2 minutes at high idle.
- d. Start the engine in the dead vehicle.
- e. Shut off the vehicle in the donor vehicle.

f. Disconnect the jumper cables in the correct sequence.

Average of above evaluations* — — — —

(*This is the final evaluation for Competency E3.)

MODULE: ELECTRICAL SYSTEMS

UNIT IV: BATTERY DIAGNOSIS AND SERVICE

UNIT IV TEST

PART I. AUTOMOTIVE BATTERIES

SECTION A. Match the terms below with their appropriate definitions.

____ 1. A mixture of sulfuric acid and water that causes chemical action in the battery cell.

____ 2. The quantity of electrons that can be delivered from an electrical system or device.

____ 3. A liquid acid mixed with water to form battery electrolyte.

____ 4. The weight of a substance compared to pure water.

____ 5. A set of negative and positive plates arranged so that, at full charge, they can produce about 2.2 volts of electron force.

____ 6. The flow of electrons from a source.

____ 7. A chemical device that produces electricity.

____ 8. Lead and oxygen combined (pbo2).

____ 9. A malleable metal that is useful as a conductor (pb).

____ 10. A by-product of the chemical charging of a battery. It is odorless and colorless yet highly explosive.

a. Battery
b. Capacity
c. Element
d. Discharge
e. Electrode
ab. Electrolyte
ac. Hydrogen gas
ad. Lead
ae. Lead dioxide
bc. Specific gravity
bd. Sulfuric acid
be. Ambient temperature

SECTION B. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 11. Battery elements are made up of lead and lead dioxide grid plates, which are suspended by a plate strap.

____ 12. A state-of-charge indicator is found on all nonserviceable batteries.

____ 13. The state-of-charge indicator is dark when the battery is charged above 75% and green when charged below 75%.

____ 14. The primary function of a battery is to store electrical energy.

____ 15. During chemical action in the battery, oxygen in the positive plate combines with hydrogen in the sulfuric acid to form water.

____ 16. One result of the chemical action within the battery is that the negative plate is changed to lead sulphate.

SECTION C. Select the best answer from the five choices listed.

____ 17. The amp hour rating indicates

a. the length of time that a fully charged battery can deliver a specific quantity of charge at 80 F.
b. the maximum voltage that a fully charged battery can produce within an hour at a temperature of 80 F.
c. the maximum amperage that a fully charged battery can produce within an hour at a temperature of 80 F.
d. the minimum voltage that a fully charged battery can produce within an hour at a temperature of 80 F.
e. none of the above.

____ 18. The cold-cranking amps rating indicates the number of amps a battery can deliver (without the cell voltage falling below 1.2 volts per cell) for thirty seconds at

a. -10°F.
b. 0°F.
c. 10°F.
d. 32°F.
e. none of the above.

____ 19. The reserve capacity minutes rating is used to indicate how long a serviceable battery could provide minimum current demand if the

a. battery has not been in service for more than six months.
b. battery has not been in service for more than one year.
c. battery reaches a temperature below -50°F.
d. battery reaches a temperature above 150°F.
e. charging system fails.

____ 20. An engine requires about 1 amp of current for

a. each cubic inch of displacement.
b. each five cubic inches of displacement.
c. each ten cubic inches of displacement.
d. each fifteen cubic inches of displacement.
e. .05 seconds of engine operation.

(NOTE: The student must obtain a minimum score of _____ on Part I of the Unit IV Test in order to receive an evaluation for Competencies E1-E4.)

PART II. CLEANING AND INSPECTING BATTERY CLAMPS, CABLES AND CONNECTORS

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 21. The battery top needs to be cleaned if a voltmeter is connected to a post and the battery top and gives a reading above 1.

____ 22. A good substance for cleaning battery tops is a paste consisting of baking soda and water.

____ 23. Battery side post cables should usually be tightened to at least 180 In.Lbs. of torque.

____ 24. Though the bolt holding the cable end to the post should be tight, there should still be a small gap in the clamp.

____ 25. If battery cable ends are defective but the rest of the cable is in good working order, replacement ends can be added to the cable.

(NOTE: The student must obtain a minimum score of _____ on Part II of the Unit IV Test in order to receive an evaluation for Competency E1.)

PART III. PERFORMING BATTERY CONDITION TESTS

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 26. A battery load test determines a battery's ability to supply a specific amount of amperes based upon its original amp hours or cold-cranking ampere capacity.

____ 27. Because surface charge is contained on the surface of the battery grids, it can provide the technician with a highly reliable battery voltage reading.

____ 28. The three-minute charge test measures battery sulfation as well as the battery's ability to recover charge.

____ 29. The hydrometer measures the sulfate content of liquid (when used in connection with batteries, the hydrometer measures the sulfate content of battery acid).

____ 30. A battery load capacity test is the only method of determining the state of charge of nonserviceable batteries.

____ 31. Three pieces of equipment needed to perform the open circuit test are a voltmeter, ohmmeter, and carbon pile.

____ 32. Two pieces of equipment needed to conduct a battery drain test are an ohmmeter and voltmeter.

____ 33. A carbon-pile tester is a device for producing a load on a battery.

____ 34. A battery static-drain test measures the amount of current that drains from the battery when all electrical systems are energized.

SECTION B. Read each of the below statements made by technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.

____ 35. Technician I says that, if a hydrometer test indicates that any or all battery cells have a specific gravity below 1.225, the battery has only a 75% charge.

Technician II says that, if a hydrometer test indicates that any or all battery cells have a specific gravity below 1.225, the battery has a full charge.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 36. Technician I says that, if a hydrometer test indicates that battery cells are equal but too low, the battery should be slowly recharged.

Technician II says that, if a hydrometer test indicates that battery cells are equal but too low, the battery may contain too much electrolyte.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 37. Technician I says that a hydrometer must be temperature compensated because temperature directly affects the density of liquids.

Technician II says that a hydrometer must be temperature compensated because temperature directly affects the specific gravity of liquids.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 38. Technician I says that, if a load test indicates that a battery has below 9.6 volts, the battery is good.

Technician II says that, if a load test indicates that a battery has below 9.6 volts, a three-minute charge test should be performed.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 39. Technician I says that, if a three-minute charge test indicates a battery's voltage is above 9.6, the battery may be good, but a load test should be performed to confirm the voltage reading.

Technician II says that, if a three-minute charge test indicates a battery's voltage is below 9.6, the battery is probably bad, but a load test should be performed to confirm the voltage reading.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 40. Technician I says that, if a hydrometer test indicates that a battery's cells vary more than 25 points, an open circuit voltage test should be performed.

Technician II says that, if a hydrometer test indicates that a battery's cells vary more than 35 points, the battery should be replaced.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 41. Technician I says that, if open circuit voltage in a battery is found to be less than 12.0 volts, the battery should be slowly recharged.

Technician II says that, if open circuit voltage in a battery is found to be more than 12.0 volts, a load capacity test should be performed.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of ______ on Part III of the Unit IV Test in order to receive an evaluation for Competency E2.)

PART IV. CHARGING AND INSTALLING A BATTERY

SECTION A. **Read each of the below statements made by technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.**

____ 42. Technician I says that a battery's rate of charge is determined by its amp hour rating.

Technician II says that a battery's rate of charge is determined by its voltage rating.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 43. Technician I says that charging rates of under 5 volts can damage the battery.

Technician II says that charging rates of over 15 volts can damage the battery.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 44. Technician I says that state of charge indicators are used to determine at least 80% charge.

Technician II says that state of charge indicators are found only on serviceable batteries.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 45. Technician I says that serviceable, dry-charged batteries must be filled with electrolyte before installation.

Technician II says that serviceable, dry-charged batteries must be charged before installation.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 46. Technician I says that, when a battery is installed, the ground cable should be connected last.

Technician II says that the ground cable should be disconnected first when removing a battery from a vehicle.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 47. Technician I says that a new battery should be brought to a 50% charge when installed.

Technician II says that, if possible, a battery should be brought to a full charge after removal.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 48. Technician I says that the EPA does not consider discarded batteries a hazardous waste if they have been drained of electrolyte.

Technician II says that the EPA considers all discarded batteries a hazardous waste.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of _____ on Part IV of the Unit IV Test in order to receive an evaluation for Competency E4.)

PART V. JUMP STARTING A VEHICLE

SECTION A. **Read each of the below statements made by technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.**

____ 49. Technician I says that a frozen battery should be jump started only if the donor battery is at full charge.

Technician II says that a frozen battery should be jump started only if it is a nonserviceable battery.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 50. Technician I says that the donor vehicle should always be running while jump starting a dead battery.

Technician II says that the donor vehicle should never be running while jump starting a dead battery.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 51. Technician I says that jump starting procedures are the same for both multiple battery and single battery vehicles.

Technician II says that multiple battery vehicles should not be jump started.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of _____ on Part V of the Unit IV Test in order to receive an evaluation for Competency E3.)

ANSWERS TO UNIT IV TEST

1. ab
2. b
3. bd
4. bc
5. c
6. d
7. a
8. ae
9. ab
10. ac
11. t
12. f
13. t
14. f
15. f
16. t
17. e
18. b
19 e
20. a
21. t
22. t
23. f
24. t
25. t
26. t
27. f
28. t
29. f
30. t
31. f
32. f
33. t
34. f
35. d
36. a
37. c
38. c
39. d
40. b
41. a
42. a
43. b
44. a
45. c
46. c
47. b
48. b
49. d
50. a
51. d

MODULE: ELECTRICAL SYSTEMS

UNIT V: STARTING SYSTEMS

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the various components of a starting system and the principles by which they work. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1. I. Identify terms and definitions associated with the starting system (Competencies F1-F3, Unit V Test).

II. Identify the basic components of the starting system and the principles by which they function (Competencies F1-F3, Unit V Test).

III. Identify the operating principles of three basic types of starting systems (Competencies F1-F3, Unit V Test).

ASE TASKS COVERED IN THIS UNIT

I. Only material that is preliminary to ASE tasks appears in this unit. No ASE tasks are covered directly.

MODULE: ELECTRICAL SYSTEMS

UNIT V: STARTING SYSTEMS

CONTENTS OF THE UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Unit introduction

E. Lesson plans

    1. Lesson 1: STARTING SYSTEM COMPONENTS

        a. Information outline

        b. Assignment sheets

            AS1-L1-UV: Starting Systems

F. Unit test

G. Answers to unit test

REFERENCES

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Derato, Frank. Electrical and Electronic Systems: Shop Manual. New York: McGraw-Hill Book Company, 1986.

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NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

  1. Students should do AS1-L2-UV before taking the Unit V Test.

B. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

  1. Battery and Cranking System, Principles of Operation (AM-84-400), 1984.

MODULE: ELECTRICAL SYSTEMS

UNIT V: STARTING SYSTEMS

INTRODUCTION: UNIT V

The automotive starting system uses all the essential components of a circuit. The battery sends electron force to the starter motor by way of large current-carrying battery cables. The starter motor is a load device, which requires heavy current flow. The starter relay and ignition switch serve as the starting system's control devices. This unit will examine how the basic starting motor functions in relationship to the other parts of the starting system.

MODULE: ELECTRICAL SYSTEMS

UNIT V: STARTING SYSTEMS

LESSON 1: STARTING SYSTEM COMPONENTS

I. Terms and definitions

A. Armature--A starter motor component that rotates between the field pole shoes.

B. Brush--A carbon conductor used to connect the moving armature to the stationary starter housing.

C. Commutator--Copper bars used to pass current to and from the carbon brushes. The commutator is part of the moving armature.

D. Electromagnet--A conductor that becomes magnetized as a result of current flowing through it.

E. Field coils--A device that produces magnetic fields. Field coils are placed around the outer housing of the starter case.

F. Magnet--A ferrous (iron) material that has the ability to attract or repel objects that are similarly charged and that have a north and south pole.

G. Magnetic flux--The magnetic lines of force around a magnet or electromagnet.

H. Magnetic poles--The north and south ends of a magnet.

I. Mica--A nonconducting, nonmagnetic material used to insulate commutator bars.

J. Overrunning clutch--One-way clutch assembly used in the starter drive. The overrunning clutch locks while cranking the flywheel during engine start-up and drive disengagement.

K. Permanent magnet--A ferrous material that has a seemingly permanent state of magnetic charge.

L. Pole shoe--Ferrous iron core of the field coil assembly. The pole shoe increases the strength of the magnetic field.

M. Relay--A device that uses a low-current switching mechanism to control a high-current path.

N. Solenoid--A magnetic coil wrapped around a moveable ferrous core. The solenoid engages large current-carrying contacts or converts electrical energy to linear mechanical energy.

O. Starter drive--A gear device used to engage the starter to the engine flywheel.

P. Starter motor--A powerful DC current motor used to engage the flywheel during cranking.

Q. Switch--A device that controls current.

II. Starting system components

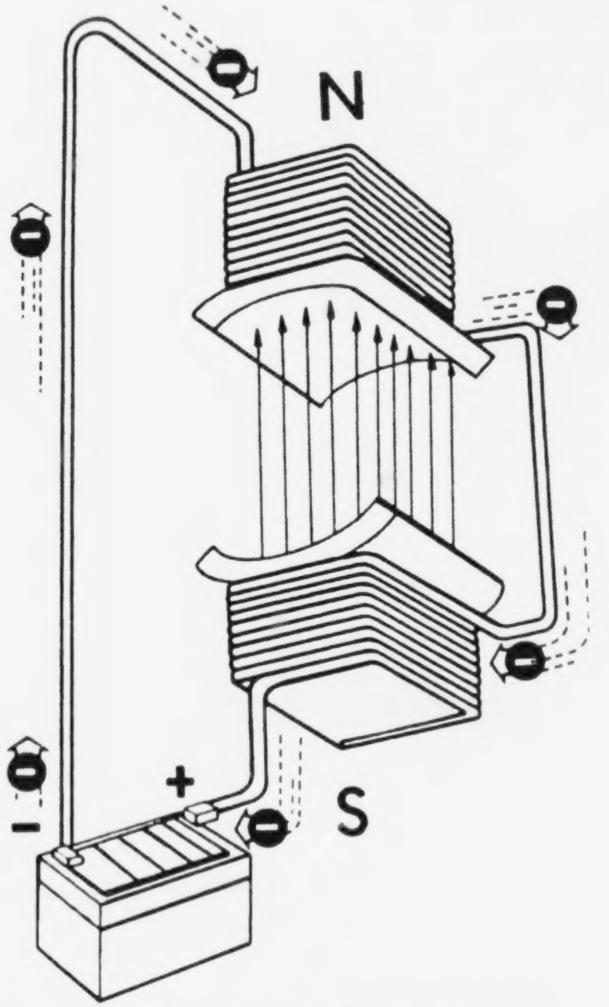
A. The starter motor

1. A starter motor is essentially a DC motor that uses gears to drive the flywheel. Operating at low RPM, the starter motor develops more than enough torque to crank the engine.

2. Electromagnetic attraction and repulsion rotate the starter's armature. The armature is attached to a shaft, which is supported by bearings, electrical energy can be converted into the mechanical energy required to crank the engine.

3. Field coils are stationary electromagnets that are used to create a magnetic field between the iron pole shoes.

   a. Forcing current through an insulated conductor wrapped around an iron pole shoe will produce a magnetic field. The magnetic field will be stronger if the two wrapped pole shoes are arranged in pairs.

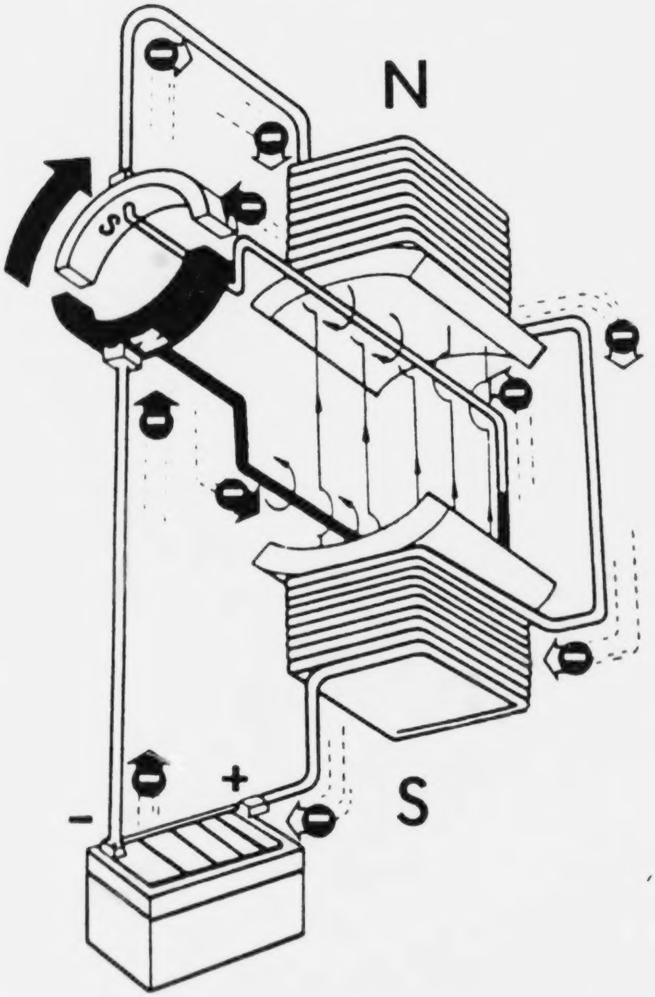


MAGNETIC FIELD BETWEEN POLES

b. The greater the current flow through the wrapped winding, the more intense the magnetic field. This dense field is called the magnetic flux.

4. If current is forced through a conductor after it is shaped into a loop and placed in the middle of the magnetic field (created by the field coils), the conductor will move. When a conductor functions in this way, it is referred to as an armature.

5. The armature moves as a result of the magnetic principle that like-charged (magnetized) particles repel and unlike-charged particles attract. The armature will turn 180 degrees before stopping because the south polarized loop will be pulled to the north field coil and the north polarized loop will be pulled to the south field coil.



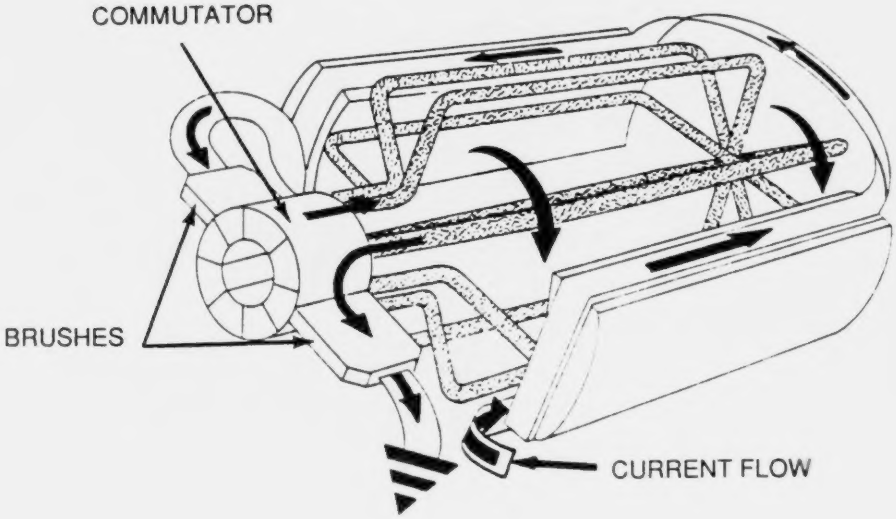
ELECTROMAGNET ROTATES BETWEEN POLES

6. The commutator and the brushes keep current flowing through the armature while it turns.

   a. Brushes used in the starter motor can be made of either carbon, a combination of carbon and copper, or a copper alloy. The brushes provide a low-resistance current path to the commutator. Spring action holds the brushes in contact with the commutator.

   b. In a four-brush starter, two brush leads will be grounded and two will be insulated.

   c. Commutators are copper strips that connect each brush to a different side of a wire loop in the armature, thus allowing current to flow into one side of the loop and out the other. Notice that, because of the magnetic force, the armature's south loop is approaching the north pole shoe. As the armature rotates, the brushes leave the commutator strip upon which they were riding. The brushes then contact the next commutator strip. This action reverses the current direction through the loop while also reversing the armature's polarity (north becomes south and south becomes north). This reverse in polarity creates a new attraction and repulsion, causing another 180 degrees of rotation.



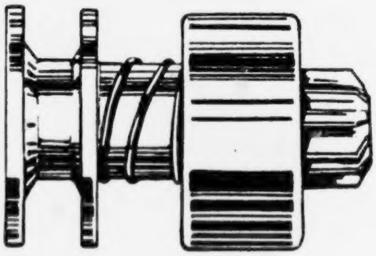
   d. Multiple commutator strips and loops are used to increase starter efficiency. The strips are separated by mica, an insulating material that prevents arcing. More than two pole shoes can be used to overlap the magnetic fields.

B. Starter drives

1. The starter drive connects the armature shaft of the starter motor to the flywheel. This connection is made when a small gear (the starter drive) on the armature shaft is engaged to a very large gear (the ring gear) on the back of the crank shaft.

2. The overrunning clutch is a roller-type (one-way) clutch that free wheels when flywheel speed exceeds drive pinion speed. The overrunning clutch will lockup when pinion speed exceeds flywheel speed, thus allowing the starter to drive the flywheel.

3. A solenoid is used to engage the drive by electromechanical action. The solenoid will be covered in a later section of this unit.

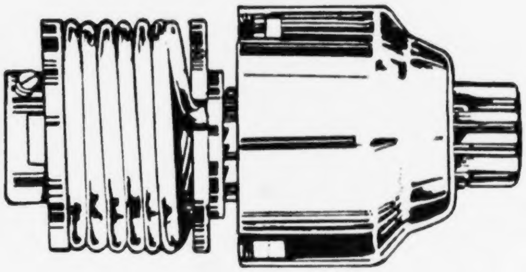


OVERRUNNING CLUTCH

4. The bendix is an older type of starter drive. The bendix drive uses inertia engagement rather than solenoid electromechanical action to force the drive pinion into engagement with the flywheel.

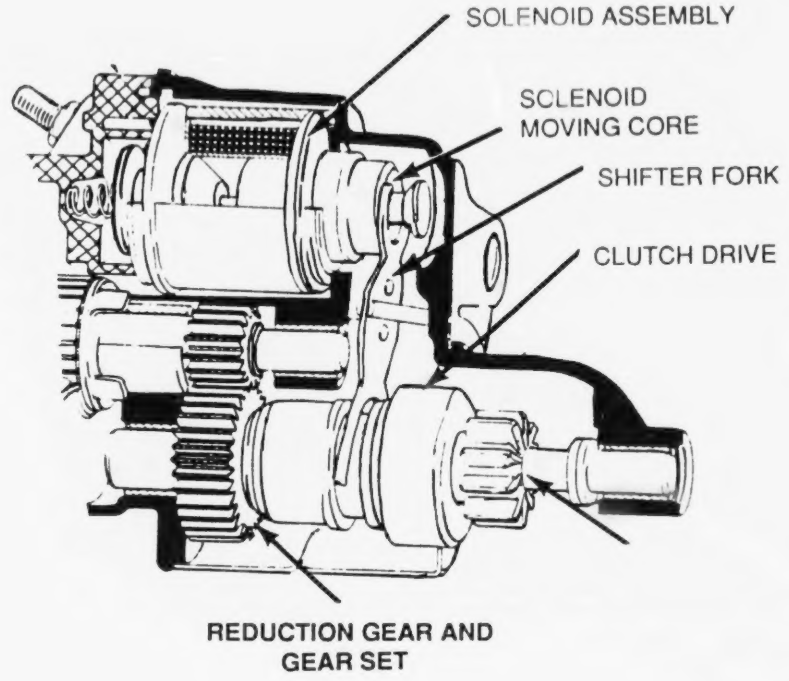
   a. In the bendix drive, a course thread actually screws the pinion into engagement when the starter motor is energized and exceeds flywheel speed.

   b. The pinion is disengaged by unscrewing the drive unit when flywheel speed exceeds starter motor speed.

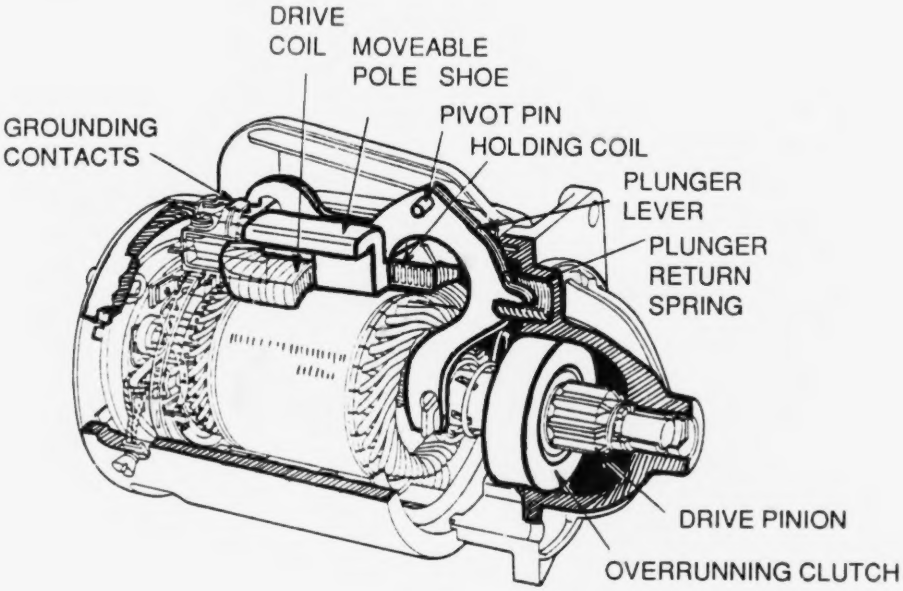


BENDIX

5. To produce greater torque, some starters use a reduction gear assembly drive that raises armature speed in relation to flywheel speed. A solenoid shift assembly is used to engage the drive pinion.


SOLENOID ASSEMBLY
SOLENOID MOVING CORE
SHIFTER FORK
CLUTCH DRIVE
REDUCTION GEAR AND GEAR SET

6. The positive-engagement drive does not have a separate solenoid; the engagement solenoid is instead part of the field coil. The pinion engagement is similar to that of a standard overrunning clutch.


DRIVE COIL
MOVEABLE POLE SHOE
PIVOT PIN
HOLDING COIL
GROUNDING CONTACTS
PLUNGER LEVER
PLUNGER RETURN SPRING
DRIVE PINION
OVERRUNNING CLUTCH

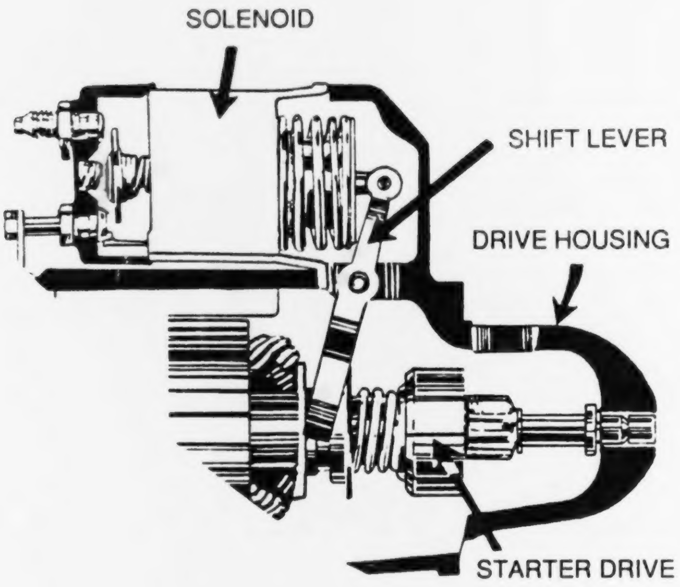
C. Solenoids

1. The primary purpose of the starter-mounted solenoid is to engage the starter drive pinion before the armature begins turning. The solenoid then disengages it after the engine is started.

   a. The solenoid is also used to connect the starter field coils to the battery during cranking.

   b. On some vehicles, the solenoid connects the battery's positive pole to the ignition system during cranking. When the solenoid does so, this connection (circuit) is referred to as the ignition resistor bypass circuit.

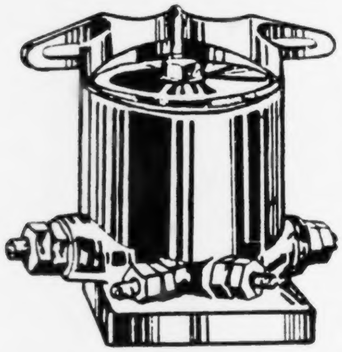
   c. The solenoid uses both a pull-in winding and a hold-in winding. The pull-in winding initiates the plunger movement and forces the starter drive into contact with the ring gear. The hold-in winding keeps the plunger and starter drive in place during cranking. The ignition switch controls the energizing of the solenoid.


SOLENOID
SHIFT LEVER
DRIVE HOUSING
STARTER DRIVE

2. Positive-engagement starter relay

   a. The positive-engagement solenoid uses a moveable pole shoe. The shoe is pulled into the field by magnetic attraction when the field is energized.

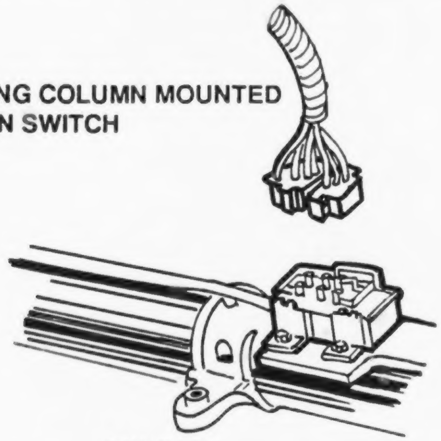
   b. Unlike the starter-mounted solenoid, a separate relay supplies battery voltage to the engagement starter relay. The ignition switch controls the engagement of the relay.



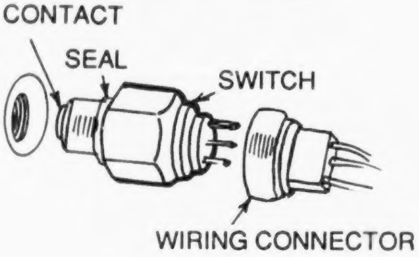
MAGNETIC ROTARY SWITCH

3. The starter switch is actually a multiple-pole rotary switch that energizes the pull-in winding of the solenoid or relay in a starter circuit.

4. In automatic transmission vehicles, the neutral safety switch allows cranking only when the transmission is in neutral or park. In manual transmission vehicles, the switch will allow cranking only when the clutch is depressed.



STEERING COLUMN MOUNTED IGNITION SWITCH



TRANSMISSION MOUNTED NEUTRAL-START SWITCH

D. Starter circuit arrangement and sequence

1. Solenoid-shift system sequence

   (NOTE: Starters using the solenoid-shift sequence are widely used on GM vehicles and are, therefore, referred to as GM-type solenoids.)

   a. When the ignition switch is rotated to the start position, current is supplied to the neutral safety switch.

   b. If the automatic transmission is in park or neutral (or if the clutch is depressed on a manual transmission) current passes through the neutral safety switch. Current is then supplied to the pull-in and hold-in windings of the solenoid. The hold-in winding has its own ground.

   c. The magnetic flux created around the pull-in winding pulls the shift plunger into the solenoid. The shift fork forces the drive pinion into engagement with the ring gear teeth.

d. As the plunger hits bottom, a copper contact connects the battery's positive cable to the motor-feed strap and to ground by way of the field winding and armature.

e. Because a battery positive now exists on both sides of the pull-in winding, there is no potential difference; current flow in the winding, therefore, stops. Until power is cut by the ignition key, the hold-in winding continues to retain the plunger.

f. Because the vehicle's battery supplies the field winding with current, attraction and repulsion occur. The attraction and repulsion rotate the armature shaft and drive the pinion gear against the ring gear, thus cranking the engine.

g. When the engine starts, the pinion free wheels by the one-way (overrunning) clutch until the ignition key is moved to the run position.

h. Current is cut off to the hold-in winding and spring tension returns the plunger to the disengaged position, thus disengaging the pinion.

2. Starting relay with positive engagement sequence

   a. When the ignition switch is turned to the crank position, battery current is provided to either the neutral safety switch or clutch-depressed switch. If the transmission is in either park or neutral (or if the clutch is depressed on manual transmission vehicles), current will pass through the safety switch and on to the starter relay, which is mounted on the fender well or fire wall.

   b. With current provided to the relay coil (and on to ground through the relay mount), the relay closes the large current-carrying contacts and allows heavy battery current to pass through the starter relay on to the positive engagement starter.

   c. Heavy battery current flows into the pull-in and hold-in windings of the positive engagement pole shoe, thus pulling the starter drive into engagement with the flywheel. When completely engaged, the pole shoe depresses a contact that opens the ground for the pull-in winding, preventing it from functioning. The pole shoe is held in engagement by the hold-in winding, which is grounded by a separate lead. With the pull-in winding dead, heavy current flows into the field coils and through the armature to ground. As a result, the engine is cranked.

3. Solenoid shift with relay sequence

   a. When the ignition switch is turned to the crank position, battery current flows through either a neutral safety switch or a clutch-depressed switch (depending upon whether the vehicle is using an automatic or manual transmission) in order to energize the coils in the solenoid.

b. With the relay coil grounded through the safety switch, the relay closes and allows battery current to flow to the solenoid mounted on the starter. When current reaches the solenoid, the pull-in and hold-in windings are engaged, thus allowing the starter drive to engage the flywheel.

c. With the solenoid contacts closed, heavy battery current is allowed to flow into the field coils and armature, thus cranking the engine.

III. The various types of starters

A. The solenoid shift starter

(NOTE: There are two types of solenoid shift starters--the traditional type and the permanent-magnet type. The traditional solenoid shift starter uses wire-wound field shoes while the permanent-magnet starter uses permanent-magnet field shoes. The permanent magnet type is fast becoming the more popular of the two.)

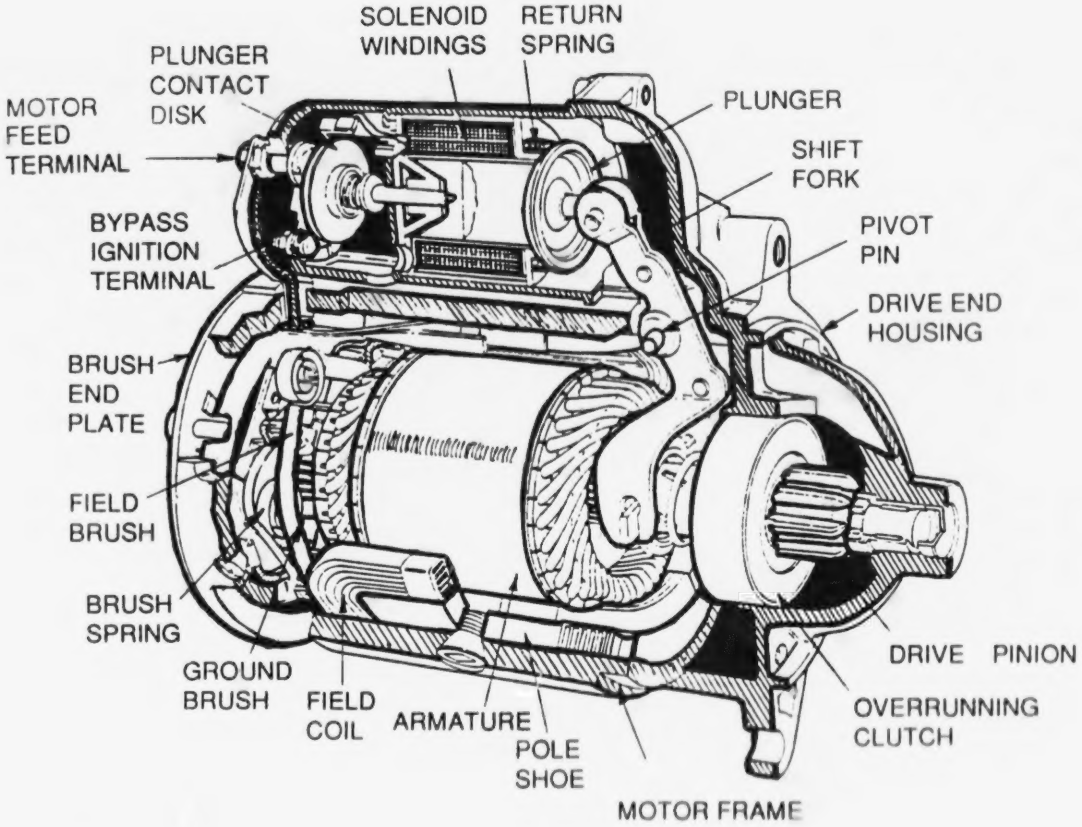
1. The solenoid and plunger pull the starter drive into engagement and connect the battery positive cable to the feed terminal of the starter motor. The solenoid and plunger may also provide ignition resistor bypass during cranking.

2. Field coils are used to produce a heavy magnetic field. Field coils may be wired either in series or in parallel to the armature and brushes.

3. The armature rotates between the field coils as a result of being mutually attracted and repelled by the magnetic force of the field coils.

4. The commutator switches the polarity of current flow through the armature, creating new attraction and repulsion, causing the armature to rotate between the field coils.

5. The brushes are carbon and copper conductors, which make an electrical connection between the armature and the stationary starter. A four-brush starter will have two negatively grounded brushes and two positively insulated brushes.


SOLENOID WINDINGS
RETURN SPRING
PLUNGER CONTACT DISK
MOTOR FEED TERMINAL
PLUNGER
SHIFT FORK
PIVOT PIN
BYPASS IGNITION TERMINAL
DRIVE END HOUSING
BRUSH END PLATE
FIELD BRUSH
BRUSH SPRING
GROUND BRUSH
FIELD COIL
ARMATURE
POLE SHOE
MOTOR FRAME
DRIVE PINION
OVERRUNNING CLUTCH

6. A sintered bronze bushing is located in the brush end frame of the starter housing. This bushing supports the rear of the armature shaft.

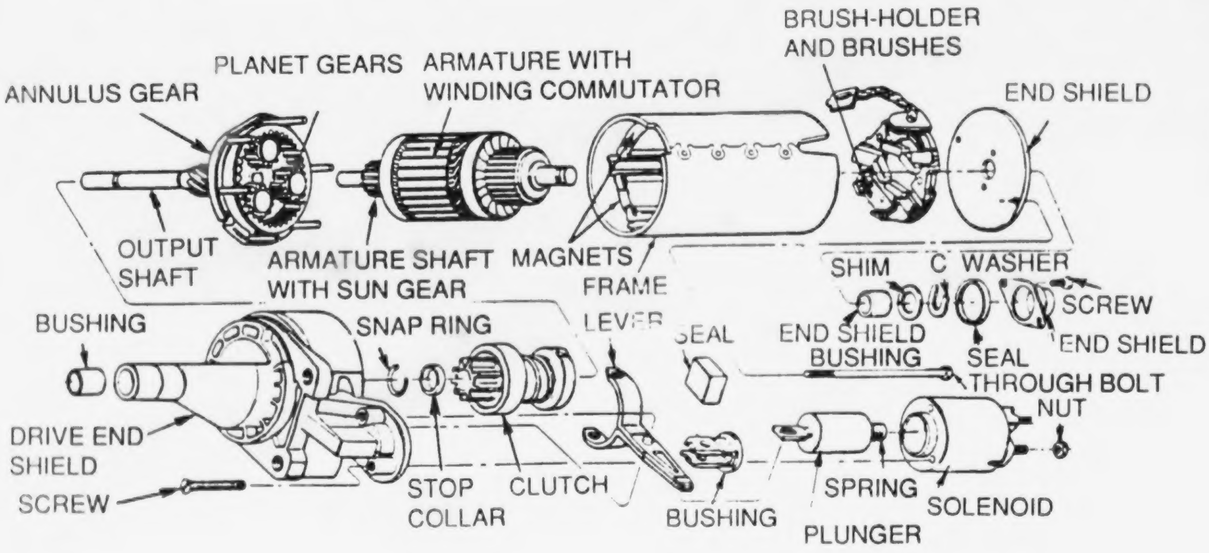
   (NOTE: The brushes are sometimes mounted on the end frame.)

7. Another sintered bronze bushing supports the other end of the armature shaft.

8. The overrunning clutch engages and disengages the engine flywheel during cranking.

9. The shift fork connects the solenoid and overrunning clutch. The fork allows the solenoid to throw the overrunning clutch and drive gear into engagement.

BOSCH STARTER MOTOR



BRUSH-HOLDER AND BRUSHES
PLANET GEARS
ARMATURE WITH WINDING COMMUTATOR
ANNULUS GEAR
END SHIELD
OUTPUT SHAFT
ARMATURE SHAFT WITH SUN GEAR
MAGNETS
FRAME
SHIM
C WASHER
SCREW
BUSHING
SNAP RING
LEVER
SEAL
END SHIELD BUSHING
SEAL
END SHIELD
THROUGH BOLT
NUT
DRIVE END SHIELD
SCREW
STOP COLLAR
CLUTCH
BUSHING
SPRING
PLUNGER
SOLENOID

B. The positive-engagement starter

1. The positive-engagement starter uses all the components found in the solenoid shift starter (with the obvious exception of the solenoid). However, the positive engagement starter also uses a moveable pole shoe, a field drive coil, and coil grounding contacts--all of which are not found in the solenoid shift starter.

   a. The moveable pole shoe is connected to the overrunning clutch linkage. The pole shoe is pulled into the field drive coil during initial starter operation, forcing the drive gear into engagement.

   b. The field drive coil is used to pull the pole shoe into engagement and to open the coil grounding contacts.

   c. The coil grounding contacts keep the armature from rotating before the moveable pole shoe is engaged. This prevents damage to the starter drive and fly wheel.

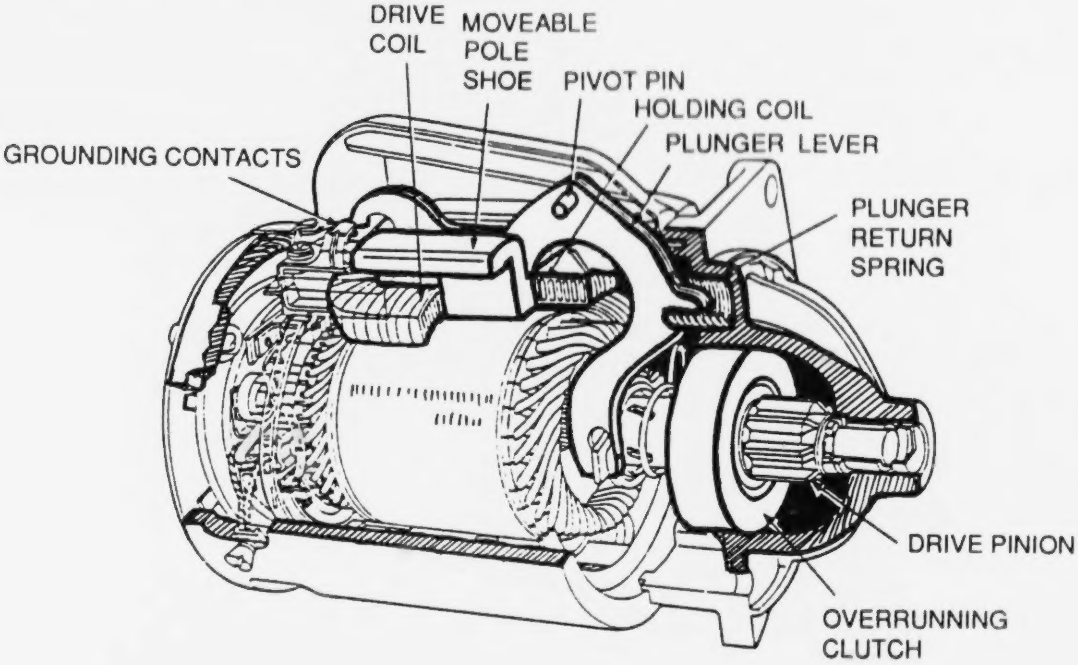
2. The positive engagement starter functions very differently from most other starters. Its operation is described below.

   a. Current arrives at the starter's motor input from the starter relay. Following the path of least resistance, it then flows through the starter's field drive coil.

   b. After becoming energized, the field drive coils pull the moveable pole shoe into position, thus engaging the starter drive.

c. When the pole shoe bottoms out, it opens the grounding contacts, forcing current through the starter motor field coils and turning the starter's armature.

d. A hold-in winding keeps the pole shoe in position until the switch is released.

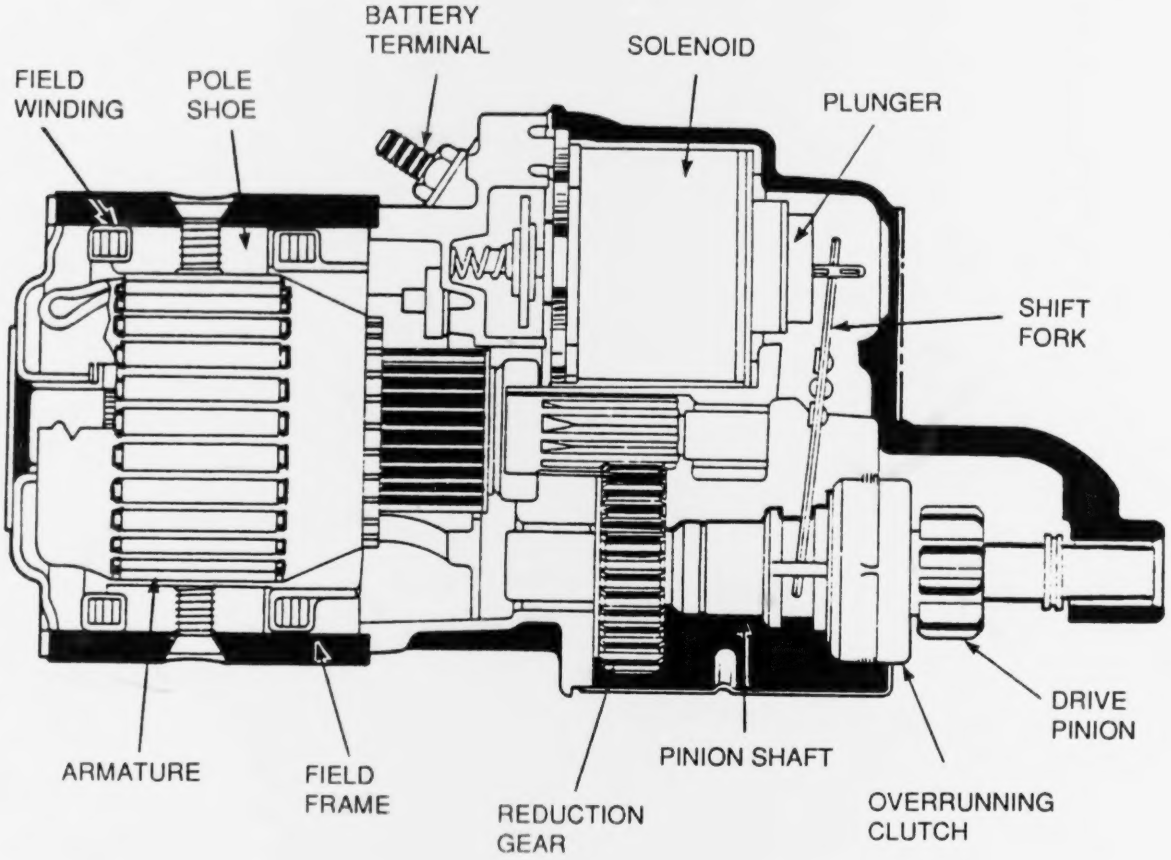

DRIVE COIL
MOVEABLE POLE SHOE
PIVOT PIN
HOLDING COIL
PLUNGER LEVER
GROUNDING CONTACTS
PLUNGER RETURN SPRING
DRIVE PINION
OVERRUNNING CLUTCH

C. The gear reduction starter motor

(NOTE: With the exception of the reduction gear and drive pinion, all internal components of the gear-reduction starter motor are the same as those found in the solenoid shift starter. Also note that, in the gear reduction starter, the starter drive is not located on the armature shaft.)

1. The reduction gear is a small driving gear that engages a large driving gear mounted on the pinion shaft. The large gear drives the overrunning clutch and drive pinion.

2. Sintered bronze bushings support the drive pinion shaft.


BATTERY TERMINAL
SOLENOID
FIELD WINDING
POLE SHOE
PLUNGER
SHIFT FORK
DRIVE PINION
PINION SHAFT
ARMATURE
FIELD FRAME
REDUCTION GEAR
OVERRUNNING CLUTCH

AS1-L1-UV

MODULE: ELECTRICAL SYSTEMS

STARTING SYSTEMS

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. The starter motor can be safely activated for how many seconds?

2. List two basic types of starter motor drives.

3. Explain why proper engine cranking RPM is important.

4. List the six main components of a starting circuit.

5. In a vehicle with a 12-volt battery, the starting system should sustain a minimum of how many volts during cranking?

6. List two jobs that the GM-type solenoid performs.

7. Explain the function of the neutral safety switch.

MODULE: ELECTRICAL SYSTEMS

STARTING SYSTEMS

(ANSWER SHEETS)

1. 30 seconds

2. Bendix, overrunning clutch

3. Allows the coil to operate properly and allows fuel and air to mix and be drawn into the cylinder.

4. Battery, starter motor, ignition switch, neutral safety switch, battery cable and wires, solenoids and relays

5. 10.2 volts

6. The GM-type solenoid engages the starter drive and also completes the current path to the starter motor.

7. The neutral safety switch prevents the engine from starting when the transmission is in gear.

MODULE: ELECTRICAL SYSTEMS

UNIT V: STARTING SYSTEMS

UNIT V TEST

SECTION A. **Match the terms below with their appropriate definitions.**

____ 1. A magnetic coil wrapped around a moveable ferrous core.

____ 2. The ferrous iron core of the field coil assembly. Its purpose is to increase the strength of the magnetic field.

____ 3. The magnetic lines of force around a magnet or electromagnet.

____ 4. A gear device used to engage the starter to the flywheel.

____ 5. A carbon conductor used to connect the moving armature to the stationary starter.

____ 6. The starter motor component that rotates the field pole shoes.

____ 7. Copper bars that collect and discharge current from the carbon brushes.

____ 8. A powerful DC current motor that engages the flywheel during cranking.

____ 9. Conductor which functions as a magnet as a result of the current flowing through it.

____ 10. A device that uses a low-current switching mechanism to control a high-current path.

a. Armature

b. Brush

c. Commutator

d. Drive starter

e. Electromagnet

ab. Flux magnetic

ac. Starter motor

ad. Pole shoe

ae. Relay

bc. Solenoid

bd. Switch

SECTION B. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 11. A magnetic field can be produced by forcing current through an insulated conductor that is wrapped around an iron pole shoe.

____ 12. In an automotive starting system, heat produced by nearby electrical coils moves the armature.

____ 13. In a four-brush starter, two brush leads will be grounded and two will be insulated.

____ 14. Commutators are copper strips that connect each brush to loops of wire wound around the solenoid.

____ 15. The overrunning clutch free wheels when the speed of the flywheel falls below that of the drive pinion.

____ 16. The primary purpose of the starter-mounted solenoid is to engage the starter drive pinion before the armature begins to turn.

____ 17. On some vehicles, the solenoid makes an electrical connection between the battery's negative terminal and the ignition system during cranking.

____ 18. The positive-engagement solenoid uses a moveable pole shoe.

SECTION C. **Select the best answer from the five choices listed.**

____ 19. A bendix drive forces the drive pinion into engagement with the flywheel by way of

a. solenoid electromechanical action.
b. inertia engagement.
c. engagement of the armature.
d. high-torque gear ratios.
e. high-efficiency heater coils.

____ 20. To produce greater torque, some starters use a reduction gear assembly drive that

a. raises flywheel speed in relation to armature speed.
b. raises armature speed in relation to flywheel speed.
c. reduces flywheel speed in relation to armature speed.
d. reduces armature speed in relation to flywheel speed.
e. keeps flywheel speed the same as armature speed.

____ 21. In the solenoid, the pull-in winding

a. initiates plunger movement and forces the starter drive into contact with the magnetic field of the pole shoe.
b. stops plunger movement and forces the starter drive into contact with the magnetic field of the pole shoe.
c. keeps the plunger and starter drive in place during engine cranking.
d. initiates plunger movement and forces the starter drive into contact with the ring gear.
e. stops plunger movement and forces the starter drive into contact with the ring gear.

____ 22. In vehicles with automatic transmissions, the neutral safety switch allows cranking only when the

a. transmission fluid levels are adequate.
b. armature is aligned with the pole shoe.
c. hold-in winding is properly grounded.
d. overrunning clutch is engaged.
e. vehicle is in neutral or park.

____ 23. In starters that use the solenoid shift system sequence, current passes through the neutral safety switch and then travels to the

a. pull-in and hold-in windings of the solenoid.
b. positive engagement starter.
c. alternator.
d. distributor.
e. overrunning clutch.

____ 24. If a technician believes the ground has been lost on a starter relay, he or she should confirm this by examining the

a. ignition switch.
b. relay mounting bracket.
c. positive battery terminal.
d. negative battery terminal.
e. printed circuit board.

____ 25. On starter motors with solenoid shift systems, the drive pinion is forced into engagement with the ring gear teeth by

a. centrifugal force.
b. the neutral safety switch.
c. the shift fork.
d. the starter relay.
e. gravity.

(NOTE: The student must obtain a minimum score of _____ on the Unit V Test in order to receive an evaluation for Competencies F1-F3.)

ANSWERS TO UNIT V TEST

1. bc
2. ad
3. ab
4. d
5. b
6. a
7. c
8. ac
9. e
10. ae
11. t
12. f
13. t
14. f
15. f
16. t
17. f
18. t
19. b
20. b
21. d
22. e
23. a
24. b
25. c

MODULE: ELECTRICAL SYSTEMS

UNIT VI: DISASSEMBLING, INSPECTING, TESTING, AND REPAIRING STARTER SYSTEMS

UNIT OBJECTIVE

After completing this unit, the student should be able to identify procedures for removing, disassembling, testing, and inspecting a starting system. The student will demonstrate mastery of the material by achieving a score of ____ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with the equipment and procedures used to test starting systems (Competency F1, Part I of the Unit VI Test).

II. Identify the equipment required to test starting systems and the proper procedures for using this equipment (Competency F1, Part I of the Unit VI Test).

III. Identify starting system test procedures (Competency F1, Part I of the Unit VI Test).

IV. Demonstrate the ability to:

   a. Diagnose the starting system and determine needed repairs (Competency F1, JS1-L1-UVI).

Lesson 2.

I. Identify the procedures for removing and installing a starter (Competency F2, Part II of the Unit VI Test).

II. Identify the procedures for disassembling a starter (Competency F2, Part II of the Unit VI Test).

III. Identify the procedures for cleaning, inspecting (testing), and repairing a starter motor (Competencies F2 and F3, Part II of the Unit VI Test).

IV. Identify the procedure for reassembling a starter (Competency F2, Part II of the Unit VI Test).

V. Demonstrate the ability to

   a. Remove and replace the starter motor (Competency F2, JS1-L2-UVI).

   b. Diagnose and repair starter motor circuit components (Competency F2, JS2-L2-UVI).

   c. Perform a starter circuit voltage drop test (Competency F1, JS3-L2-UVI).

d. Perform needed starter motor service (Competency F3, JS4-L2-UVI).

e. Perform starter motor bench test (Competency F3, JS5-L2-UVI).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks F015-F026.

MODULE: ELECTRICAL SYSTEMS

UNIT VI: DISASSEMBLING, INSPECTING, TESTING, AND REPAIRING STARTER SYSTEMS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: TESTING AND DIAGNOSING THE STARTER SYSTEM

    a. Information outline

    b. Job sheets

        JS1-L1-UVI: Diagnosing the Starter System

2. Lesson 2: REMOVING, DISASSEMBLING, INSPECTING, AND REPAIRING A STARTER

    a. Information outline

    b. Assignment sheets

        AS1-L2-UVI: Procedure for Removing and Reinstalling the Starter Motor
        AS2-L2-UVI: Procedure for Diagnosis and Repair of Starter Circuit Components
        AS3-L2-UVI: Procedure for Starter Motor Service

    c. Job sheets

        JS1-L2-UVI: Removing and Replacing Starter Motors
        JS2-L2-UVI: Diagnosing and Repairing Starter Circuit Components
        JS3-L2-UVI: Performing a Starter Circuit Voltage Drop Test
        JS4-L2-UVI: Servicing a Starter Motor
        JS5-L2-UVI: Bench Testing a Starter Motor

E. Unit test

F. Answers to unit test

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NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Have students do AS1-L2-UVI in conjunction with JS1-L2-UVI; AS2-L2-UVI in conjunction with JS2-L2-UVI; and AS3-L2-UVI in conjunction with JS4-L2-UVI.

B. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

   1. Battery and Starting System Testing (AM-84-420), 1984.

MODULE: ELECTRICAL SYSTEMS

UNIT VI: DISASSEMBLING, INSPECTING, TESTING, AND REPAIRING STARTER SYSTEMS

LESSON 1: TESTING AND DIAGNOSING THE STARTER SYSTEM

I. Terms and definitions

A. Continuity test--A test performed with a self-powered continuity light or a low-scale ohmmeter. The continuity test determines the presence of a current path in an electrical component or circuit.

B. Current-draw test--An operational test that measures the total current used by a load device.

C. Ground circuit resistance test--A test that measures the resistance between an electrical component and the negative (ground) terminal of the battery.

D. Inductive ammeter--An ammeter that indirectly measures the rate of current flow by responding to the magnetic field around a conductor.

E. Insulated-circuit resistance test--A test that measures the circuit resistance between the positive terminal of the battery and the input terminal of the electrical load device.

F. Relay test--A test that measures the ability of the relay to function adequately. The relay test can be either an operational or resistance test.

G. Remote starter switch--A heavy current-carrying switch that serves as a substitute for the ignition switch during an operational test of the starting system.

H. Resistance test--A method of detecting continuity and shorts within a circuit. In a resistance test, an ohmmeter determines continuity in an electrical component or circuit.

I. Solenoid test--An operational or resistance test that measures the ability of the solenoid to function adequately.

J. VAT--A testing device consisting of a voltmeter, an ammeter, and a carbon pile. The VAT is used for testing batteries, starting systems, and charging systems.

K. Voltmeter--A meter used to measure circuit voltage, voltage drop, or circuit resistance by determining parallel voltage drop in the starting system.

II. Starter test equipment

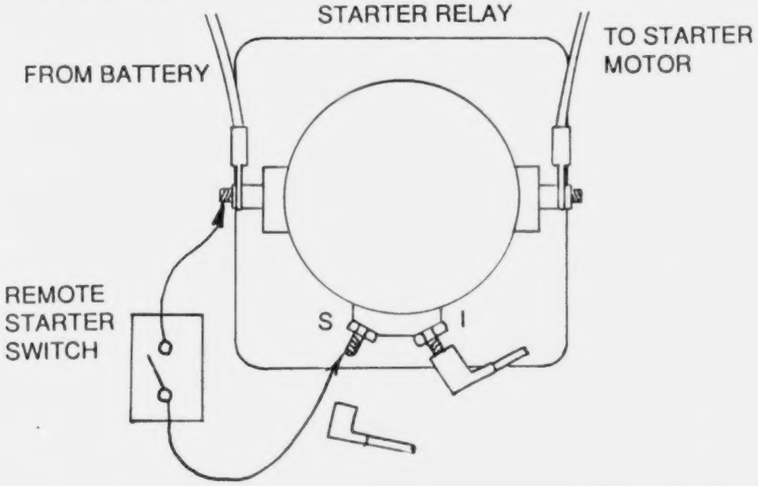
A. A voltmeter with two volt ranges is needed to test a starter. A 0-20 volt range is required to measure battery voltage during the starter draw test. An 0-3 volt range is required for a circuit resistance test (voltage drop test).

B. An ammeter (usually an inductive ammeter) is used to measure starter draw. The ammeter must be capable of measuring as much as 500 amps.

C. A low-scale (RXI) ohmmeter is used to perform a variety of trouble-shooting functions from determining continuity of a circuit to checking for shorts and grounds.

D. A self-powered (battery-powered) continuity light is used to check for opens in a variety of starter tests.

E. A single pole single throw contact switch (a relay) is used to switch heavy current flow during a starter test.



F. A VAT (BST) tester is needed to perform a starter test. The VAT contains a heavy-current ammeter, a high-range and low-range voltmeter, a carbon pile, and sufficient leads and switches to select tester operation.

III. Starter system test

A. Starter current-draw test

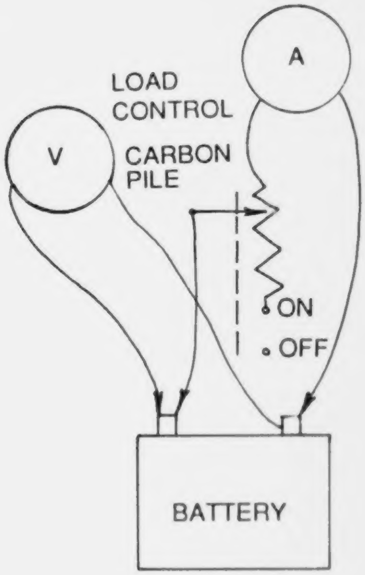
1. The starter-current draw test measures the amount of current that the starter uses in order to crank the engine for 15 seconds.

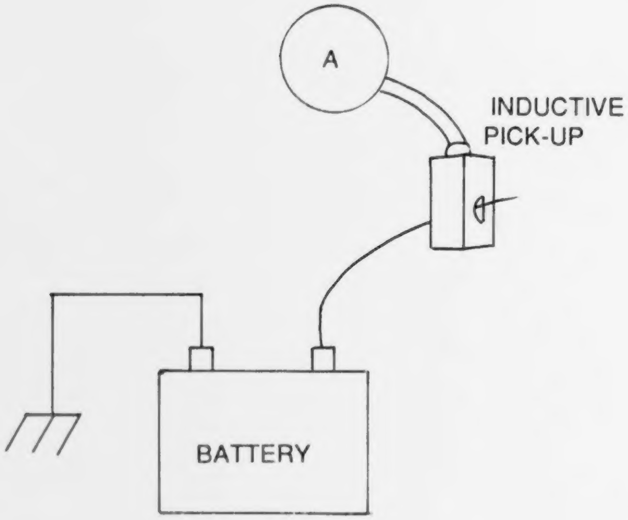
a. The amount of current required to crank the engine for 15 seconds will be determined by the following: the compression of the engine; the number of cylinders in the engine; and the cranking efficiency of the engine components.

b. During the starter current-draw test, battery voltage must be monitored to ensure that it does not fall below 10.2 volts.

(NOTE: When battery voltage drops below 10.2 volts, the battery is at an insufficient state of charge.)

c. During the starter current-draw test, the ignition system should be disabled to prevent the engine from starting.





2. Procedure for starter current-draw test

   a. Connect a voltmeter in parallel between the positive and negative battery terminals. (Be sure to observe correct polarity.)

   b. Connect a high-range ammeter. If the ammeter is a shunt or series type, connect it in series from the battery positive terminal to the positive cable end. If the ammeter is an inductive type, put the inductive clamp around the negative cable.

   c. Disable the ignition system.

      (**CAUTION:** To ensure that high-voltage arcing does not occur in the coil secondary lead, disconnect distributor battery lead.)

   d. Use a clock or watch capable of measuring seconds. Observe the voltmeter and ammeter readings while the engine is cranked for 15 seconds.

      (NOTE: An assistant should crank the engine while the technician observes the voltmeter and ammeter readings.)

   e. If battery voltage falls below 10.2 volts at any point during the 15-second period, discontinue the test. Attach charger to the battery, and set at medium rate. Repeat the test. If the battery voltage still falls below 10.2 volts, perform a battery load capacity test.

   f. During cranking, observe the ammeter's highest reading and compare it either to the table below or to the manufacturer's specifications.

AMP READING TABLE

4 cylinder	6 cylinder and small V-8	large V-8
less than 150 amps	less than 200 amps	less than 250 amps

B. Starter insulated-circuit resistance (voltage drop) test

1. By measuring the parallel voltage drop across an insulated circuit, the starter insulated-circuit resistance test reveals the internal cable resistance and the amount of resistance added to the circuit by the battery cable connections.

2. Starter insulated-circuit test procedure

   (NOTE: The following connections are for a negatively grounded starter system. The connections must be reversed for a positively grounded starter system.)

   a. Set voltmeter on lowest scale.

   b. Connect the voltmeter's positive test lead to the battery positive post.

   c. Connect the voltmeter's negative test lead to the starter terminal.

   d. While cranking the engine, observe the voltmeter readings.

      (NOTE: The readings should be within either the manufacturer's specifications or those in the following chart.)

Voltage drop in the insulated starter circuit

	6-volt system	12-volt system
Each cable	0.1	0.2
Each connection	0.0	0.0
Each switch	0.1	0.1
Starter solenoid switch	0.3	0.3
Total circuit voltage drop	0.4	0.5

C. Procedure for performing a voltage drop test on the starter's power circuit

1. Select 15-volt scale on voltmeter.

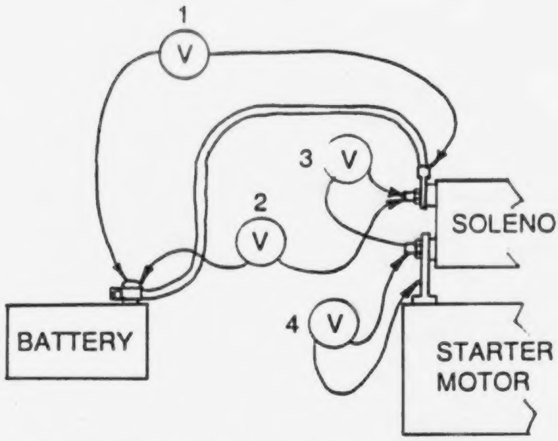
2. Connect the negative voltmeter lead to the starter motor input (after the solenoid or relay).

3. Connect the positive voltmeter lead to the battery's positive post.

4. Crank the engine.

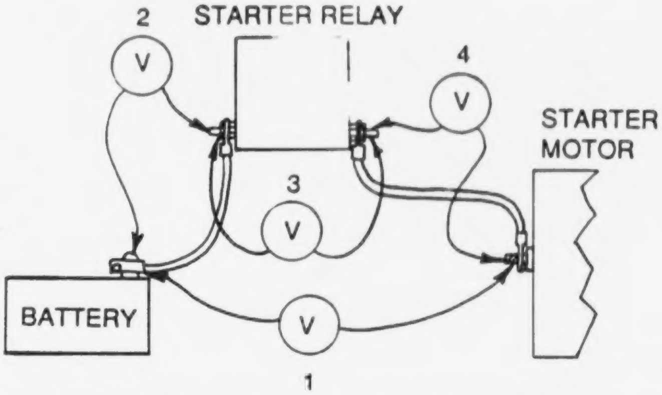
5. Select the lowest voltmeter scale while cranking engine.

6. Voltmeter reading should be less than .5 volts.


1
V
3
V
2
V
SOLENOID
4
V
BATTERY
STARTER
MOTOR

MEASURING INSULATED-SIDE VOLTAGE DROPS ON A SYSTEM WITH A SOLENOID

(NOTE: To isolate a high resistance connection or cable, trace the current path back to the battery, one connection at a time.)


2
STARTER RELAY
V
4
V
STARTER
MOTOR
3
V
BATTERY
V
1

MEASURING INSULATED-SIDE VOLTAGE DROPS ON A SYSTEM WITH A STARTER RELAY

D. Procedure for starting system ground circuit resistance (voltage drop) test

1. Connect the voltmeter positive lead to the starter case.

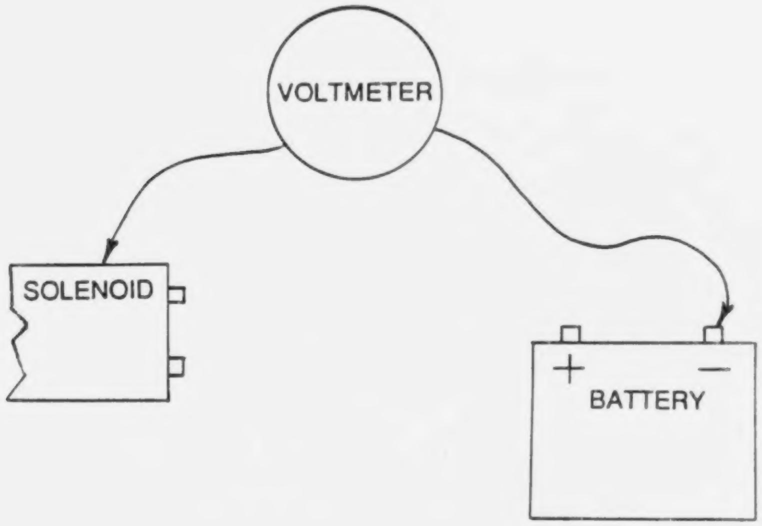
   (NOTE: To ensure a good connection, scrape the starter case where the connection is made.)

2. Connect the voltmeter's negative lead to the battery's negative post.

3. Connect the positive voltmeter lead to the starter motor case.

4. Observe voltmeter reading while cranking engine.

5. The voltmeter reading should be less than .2 volts.



E. Starter solenoid test

1. By testing the starter solenoid, the technician can determine the ability of the relay to engage the high-current contacts. Either a jumper test or a resistance test can be performed on the solenoid.

2. Procedure for performing a jumper test on a solenoid

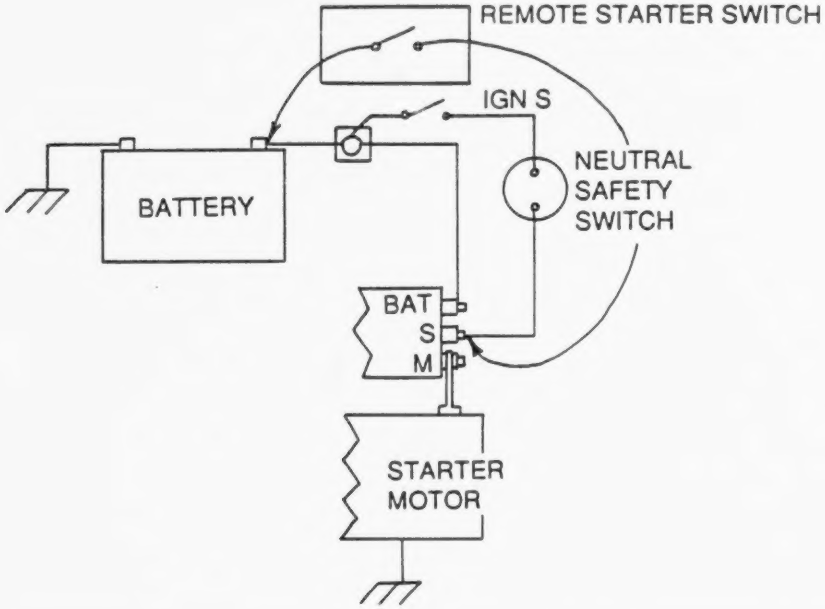
   a. Make sure the starter relay is either in its proper circuit or hooked to a high-current battery charger.

   b. Using an old screw driver or a remote starter switch, momentarily connect the battery's positive cable to the solenoid's relay connection.

   c. A positive-engagement starter relay will click loudly each time it receives current, thus cranking the engine.

d. A solenoid-engagement starter relay will loudly engage the starter drive and cause the starter to rotate in a free-running or cranking state.

e. The relay solenoid-engagement starter will click when cranking the engine.


REMOTE STARTER SWITCH
IGN S
NEUTRAL SAFETY SWITCH
BATTERY
BAT
S
M
STARTER MOTOR

3. Procedure for performing a resistance test on a positive-engagement relay

   a. Remove the relay or solenoid from the circuit or starter so that a continuity test can be performed on the hold-in or pull-in windings.

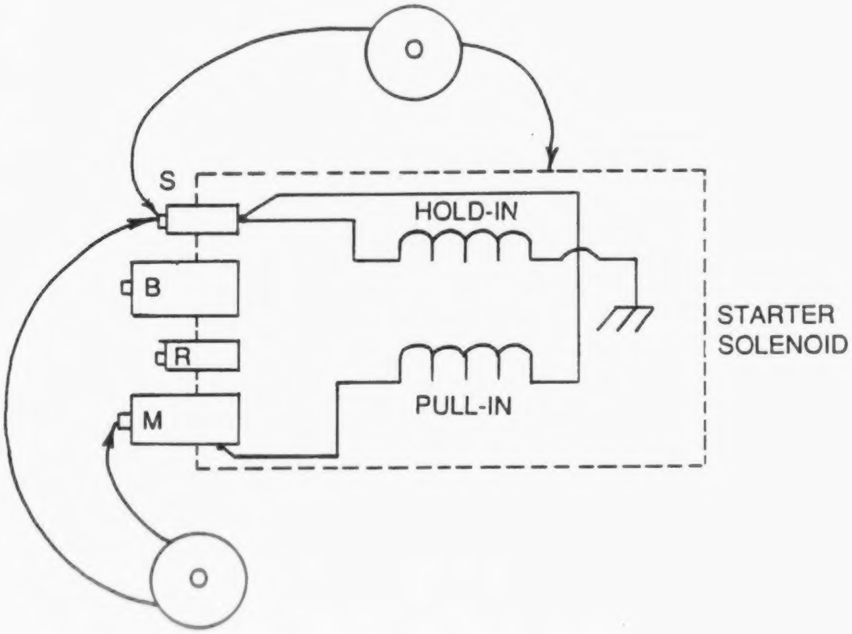
   b. Select RXI scale on the ohmmeter.

   c. Connect one ohmmeter lead to the relay's ignition start terminal.

   d. Connect the other ohmmeter lead to the relay's mounting frame.

e. Ohmmeter reading (resistance) should be low (but not "0" ohms). A low reading indicates continuity through the relay coil.

(NOTE: The resistance of the positive-engagement relay can also be determined with a self-powered test light. The procedure is basically the same as described above. If test light comes on, the circuit's continuity is established.)



F. Starter relay test

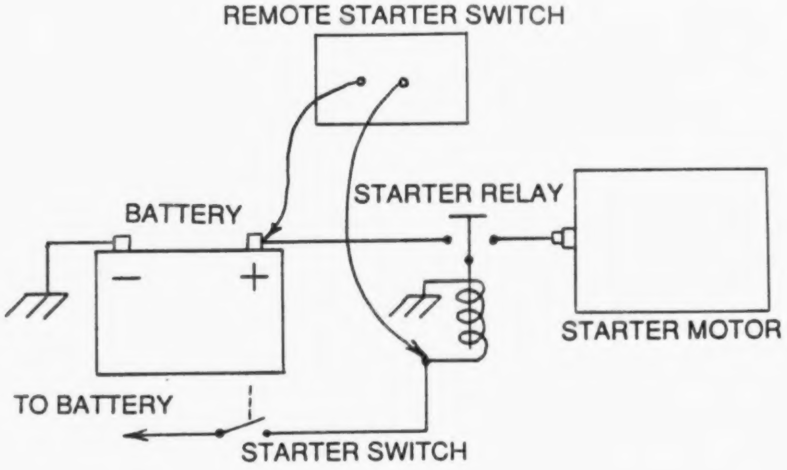
1. By testing the starter relay, the technician can determine the ability of the relay to engage the high-current contacts. Either a jumper test or a resistance test can be performed on the solenoid.

2. Procedure for performing a jumper test on a relay

   a. Make sure the starter relay is either in its proper circuit or hooked to a high-current battery charger.

   b. Using an old screw driver or a remote starter switch, momentarily connect the battery's positive cable to the relay (S) terminal.

c. The relay will click loudly each time it receives current, thus cranking the engine.


REMOTE STARTER SWITCH
BATTERY
STARTER RELAY
−
+
STARTER MOTOR
TO BATTERY
STARTER SWITCH

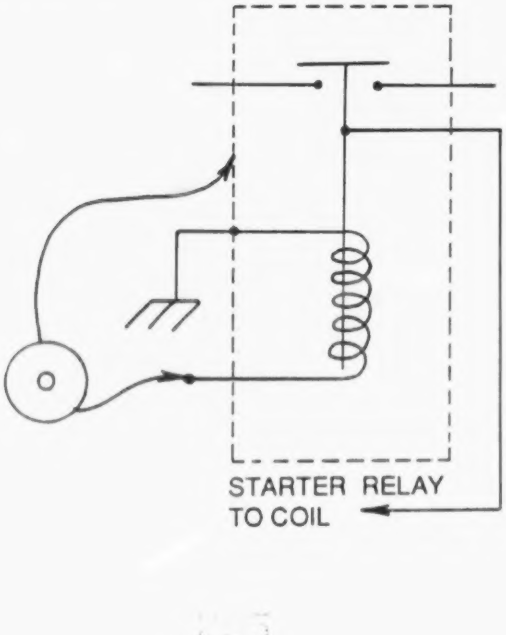
3. Procedure for performing a starter relay resistance test

   a. Select RXI scale on ohmmeter.

   b. Connect one lead to the ignition switch (S) terminal on the relay.

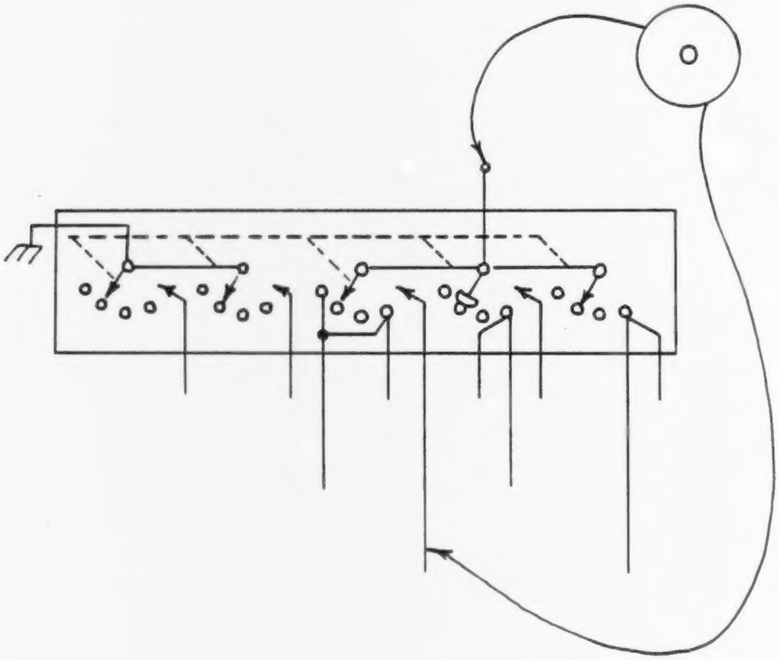
   c. Connect other lead to the grounded relay bracket. Ohmmeter reading should be low but not "0", indicating continuity of the coil.

   (NOTE: A self-powered test light can be used in the above tests. The test light will come on to indicate continuity.)


O
STARTER RELAY
TO COIL

F. Procedure for ignition switch test (with ignition switch removed)

1. Select RXI scale on ohmmeter.
2. Connect one ohmmeter lead to the battery feed terminal.
3. Connect the other ohmmeter lead to the "run" terminal.
4. Turn ignition switch to the "run" position. Ohmmeter reading should be 0.
5. Disconnect the ohmmeter lead from the "run" terminal and then connect it to the start terminal.
6. Turn ignition switch to the start position. An ohmmeter reading of 0 indicates continuity.
7. Repeat the above test for any internal ignition switch connections that may be faulty.

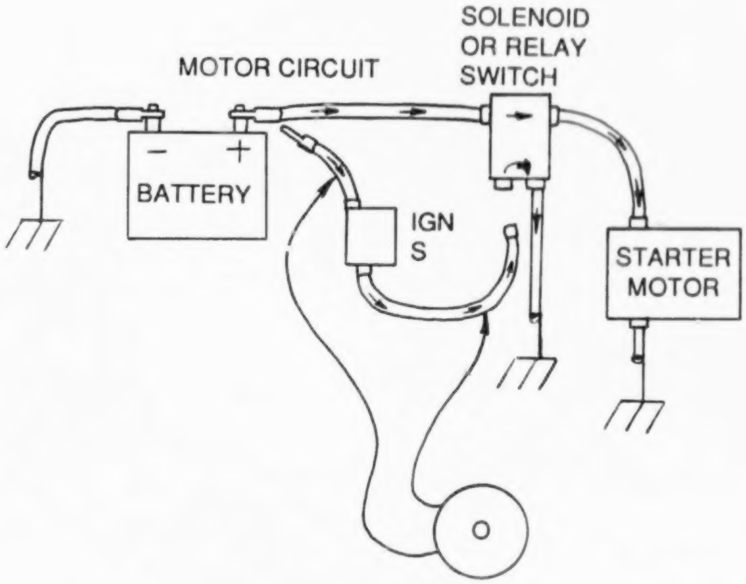


G. Procedure for wiring harness resistance test (ignition/start)

1. Select RX1 scale on ohmmeter.
2. Disconnect battery cables.

   (**CAUTION:** Always disconnect negative battery cable first.)

3. Connect one ohmmeter lead to the positive battery cable.
4. Disconnect the start terminal wire from the solenoid terminal.
5. Connect the other ohmmeter lead to the start terminal wire.
6. Turn ignition switch to the start position. An ohmmeter reading of less than .2 ohms indicates normal resistance.


SOLENOID OR RELAY SWITCH
MOTOR CIRCUIT
−
+
BATTERY
IGN S
STARTER MOTOR
O

JS1-L1-UVI

MODULE: ELECTRICAL SYSTEMS

DIAGNOSING THE STARTER SYSTEM

Equipment:

VAT
Selected vehicle
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Conduct a visual inspection of the starter circuit.

   a. Battery OK __

   b. Battery hold down OK __

   c. Battery terminal OK __

   d. Battery cables OK __

   e. Control circuit OK __

   NOTE: If any component is not OK, make needed repairs before proceeding.

3. Perform battery state-of-charge test. For the proper procedure, refer to JS3-L2-UIV in the Electrical Systems Module. __ __ __ __

   According to this test, the battery is:

   OK ___ NOT OK ___

   (NOTE: If the battery is not OK, recharge or replace it.)

4. Perform a load test on the battery. For the proper procedure, refer to JS4-L2-UIV. __ __ __ __

   Record observation

   load test amps _______

   load test volts _______

According to the above test, the battery is:

OK ___ NOT OK ___

(NOTE: If the battery is not OK, recharge or replace it.)

5. Perform starter current draw test. Follow the procedure outlined below. _ _ _ _

   a. Estimate the cranking amps required for the engine being tested.

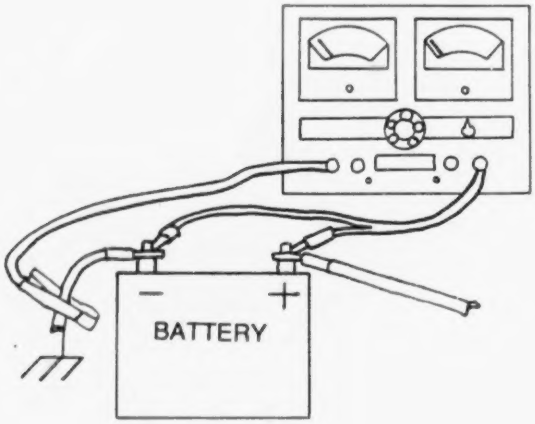
      number of cylinders _____

      cubic inch displacement ___

      estimated amp draw _____

   b. Attach VAT leads according to the below illustration or the tester instructions.

   c. Disable the ignition system.



   d. Crank the engine for 15 seconds while observing the voltmeter and ammeter readings. Record observations.

      (NOTE: Observe meter reading just before cranking is stopped.)

      Volts ___ Amps ___

   e. According to this test, does the starter motor use an acceptable amount of current to crank the engine?

      Yes __ No __

f. If answer is No, recommend steps that can be taken to correct the problem.

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency F1. Final evaluation for F1 will be made at the end of JS3-L2-UVI.)

MODULE: ELECTRICAL SYSTEMS

UNIT VI: DISASSEMBLING, INSPECTING, TESTING, AND REPAIRING STARTER SYSTEMS

LESSON 2: REMOVING, DISASSEMBLING, INSPECTING, AND REPAIRING A STARTER

I. Procedure for removing and installing a starter

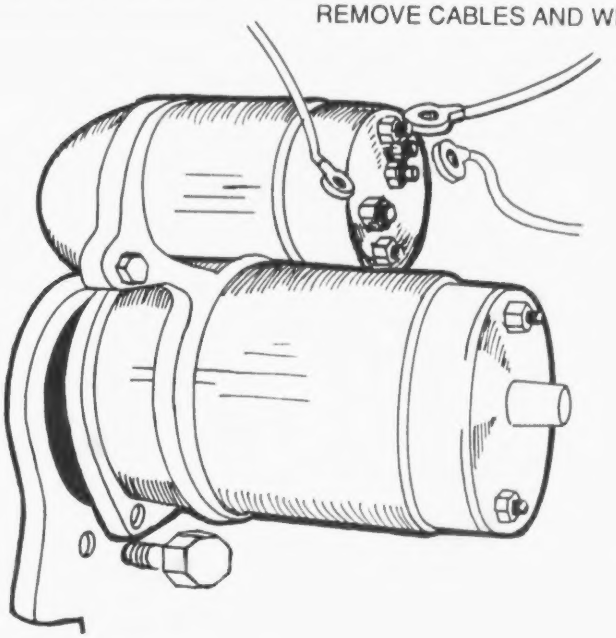
A. Disconnect the battery ground cable.

B. Raise the vehicle and safely secure it.

C. Remove all cables and electrical wires from the starter.

(NOTE: The starter may have to be partially lowered from the vehicle before the starter wires and cable can be removed. Accessory components and exhaust pipes may also have to be loosened to allow for easy removal of the starter.)

D. Remove starter retaining bolts and brackets.



E. Remove the starter from the engine.

(**CAUTION:** Starters are very heavy. Serious injury can result from handling a starter improperly.)

F. To install a starter, merely reverse the removal procedure.

(NOTE: It is sometimes necessary to place shims between the starter and the engine block.)

II. Procedure for disassembling a starter

A. Disconnect field coil connectors from solenoid.

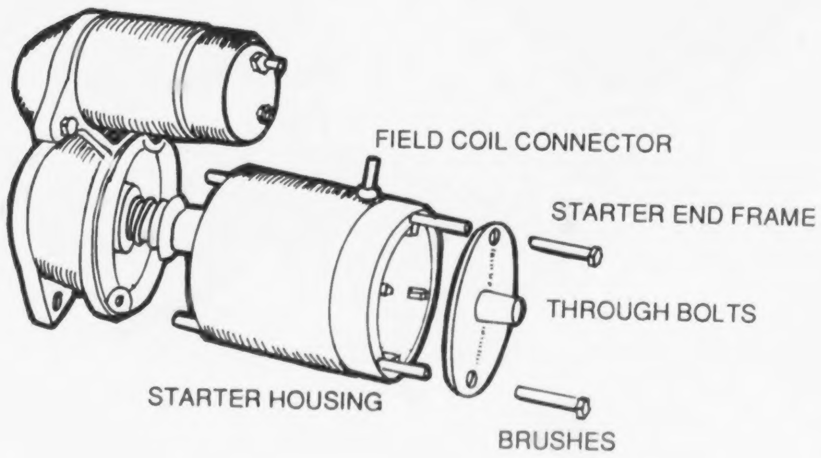
B. Mark housing and end frames for reference during reassembly.

C. Remove through bolts.

D. Remove starter-end frame.

E. Remove the starter case by pulling it over the back of the armature.

F. Remove the armature and drive assembly from the drive housing.

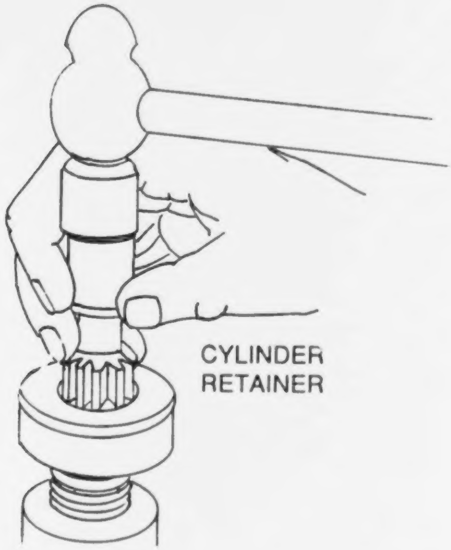

FIELD COIL CONNECTOR
STARTER END FRAME
THROUGH BOLTS
STARTER HOUSING
BRUSHES

(NOTE: Sometimes the solenoid and shift lever assembly must be removed before removing the drive assembly and armature.)

G. Following the procedure outlined below, remove the starter drive from the armature shaft.

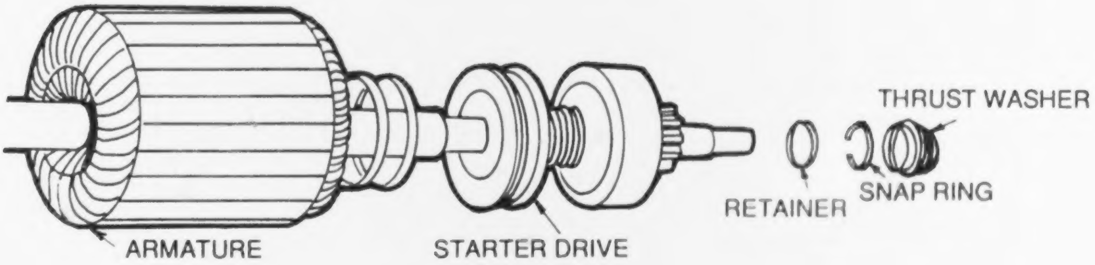
1. Remove thrust washer.

2. Tap retainer toward armature to free the snap ring.


CYLINDER
RETAINER

3. Remove snap ring and retainer.

4. Remove starter drive and assist spring.


THRUST WASHER
RETAINER
SNAP RING
ARMATURE
STARTER DRIVE

5. Remove starter brushes, if required.

III. Cleaning, inspecting (testing), and repairing a starter

A. Cleaning starter components

1. Wash starter parts with clean cloths and electric motor cleaner only.

(**CAUTION:** Starter parts will be damaged if washed in solvent.)

2. Check starter frame for solder thrown from the armature connections.

3. Neatly arrange all starter components for inspection.

B. Procedure for inspecting and testing starter components

1. Check starter bushing for looseness. Replace bushing if required.

2. Check starter brushes for wear.

   (NOTE: Brushes worn to over half their original length should be replaced.)

3. Check the starter drive.

   a. Check gear teeth for wear.

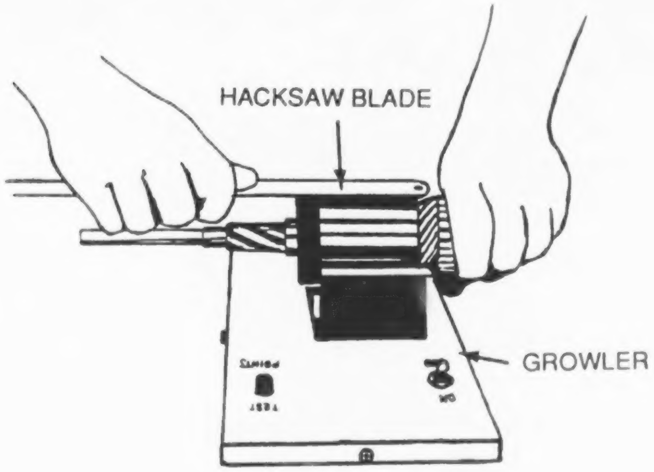
   b. Check bushing for wear.

   c. Make sure the starter drive pinion gear turns freely in one direction and locks when turned in the other direction.

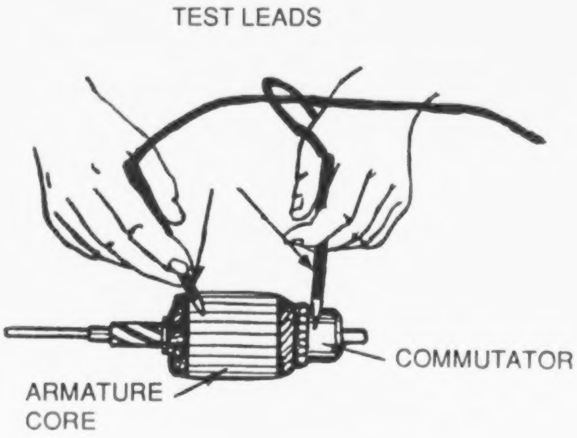
4. Inspect armature commutator and recondition as required.

   (NOTE: If the armature commutator is rough or out-of-round, use suitable equipment to turn it down.)

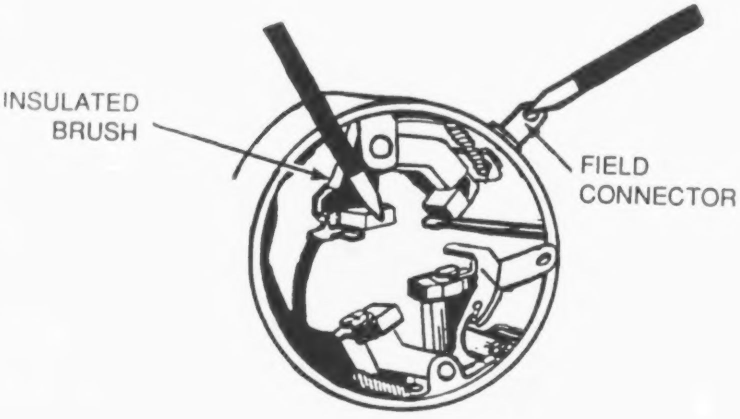
5. When checking the armature for shorts, place the armature on a growler. Rotate the armature while holding a hacksaw blade over the armature core. If the blade vibrates, the armature is shorted and should be replaced.



6. Check armature for ground by placing one lead of a self-powered test light on the armature core or shaft, and the other on each segment of the commutator. If the light comes on, the armature is grounded and should be replaced.


TEST LEADS
COMMUTATOR
ARMATURE CORE

7. Check field coil for opens by placing one lead of a self-powered test light on the insulated brush and the other on the field-connection tab. If the light does not come on, the field coils are open and should be replaced.


INSULATED BRUSH
FIELD CONNECTOR

8. Using the below procedure, check field coil for ground.

   a. Disconnect the shunt field coil and/or self-energizing switch. Isolate the shunt field coil from the starter case.

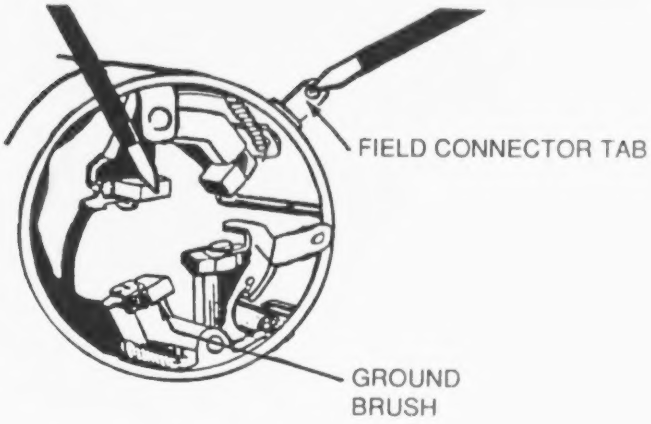
   b. Touch one self-powered test light lead to either of the shunt field wires. Touch the other lead to the starter frame.

   c. If the test light comes on, the field coils are grounded and should be replaced.

   d. The field coils can also be checked for ground by touching one self-powered test light lead to the field connector tab or post, and touching the other lead to the starter frame.

   e. If the test light comes on, the field coils are grounded and should be replaced.

   (NOTE: Both of the above procedures work equally well.)



9. After all parts have been inspected, tested and (if necessary) replaced, the starter can be reassembled and reinstalled.

IV. Procedure for reassembling a starter

   A. Install bushings as needed.

   B. Install pole and pole shoes as needed.

   C. Install starter drive.

D. Lube bushings and armature shaft.

E. Install armature.

F. Install brushes.

G. Install end frames.

MODULE: ELECTRICAL SYSTEMS

PROCEDURE FOR REMOVING AND REINSTALLING THE STARTER MOTOR

Instructions: Do the following tasks and answer the following questions on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing the starter motor from the vehicle to be serviced.
3. Explain how to check the pinion drive to flywheel/flexplate teeth clearance. Specify the amount of clearance that the vehicle's manufacturer allows.
4. Explain what corrective action should be taken if the clearance between the pinion drive and flywheel/flexplate teeth is not within the manufacturer's specifications.
5. Develop a written procedure for reinstalling the starter motor. Include the torque specifications for the mounting bolts.

MODULE: ELECTRICAL SYSTEMS

PROCEDURE FOR DIAGNOSIS AND REPAIR OF STARTER CIRCUIT COMPONENTS

Instructions: **Do the following tasks and answer the following questions on a separate sheet of paper.**

(HINT: Use an appropriate service manual and the information in Units V and VI of this module.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for testing the ignition switch on the vehicle to be serviced.
3. Develop a written procedure for testing the neutral safety switch on the vehicle to be serviced.
4. Explain how to adjust a neutral safety switch properly.
5. Explain the differences between the two types of electromagnetic switches used in starter systems (relay and solenoids).
6. Develop a written procedure for testing the electromagnetic switch on the vehicle being serviced.

MODULE: ELECTRICAL SYSTEMS

PROCEDURE FOR STARTER MOTOR SERVICE

Instructions: Do the following tasks and answer the following questions on a separate sheet of paper.

(HINT: Use an appropriate service manual and the information in Units V and VI of this module.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for disassembling the starter motor to be serviced. List any special tools that may be required.
3. Develop a written procedure for testing the components in the starter motor to be serviced.

   (HINT: Use the following chart to complete this assignment sheet.)

   A. Check armature.
      1. Growler test
      2. Continuity (with 110V test light)
         a. Between commutator segments
         b. Commutator to armature shaft
         c. Armature shaft to armature
   B. Check poles continuity.
      1. Pole winding to case.
      2. Between ends of pole windings.
   C. Check armature shaft straightness.
   D. Check armature shaft front bushing.
   E. Check armature shaft rear bushing.
   F. Check starter drive.
      1. Pinion gear
      2. One way clutch
      3. Internal flute guide

   G. Check condition of flutes on armature shaft.

   H. Check brush condition.

   I. (On Ford) Check moveable pole shoe.

   J. (On Ford) Check moveable pole contact set.

   K. (On GM/Chrysler) Check starter drive shift fork.

4. Develop a written procedure for assembling the starter motor that was disassembled in item 1 of this assignment sheet. List any special tools that may be required.

JS1-L2-UVI

MODULE: ELECTRICAL SYSTEMS

REMOVING AND REPLACING A STARTER MOTOR

Equipment:

Hand tools
Hoist
Serviceable vehicle
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Complete AS1-L2-UVI. __ __ __ __

2. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

3. Place the car securely on safety stands or lift it with a hoist. __ __ __ __

   (**CAUTION**: Remove the negative battery cable before raising the vehicle.)

4. Following the procedure outlined below, remove, clean, and inspect the starter motor. __ __ __ __

   a. Using the procedure developed in AS1-L2-UVI, remove the starter motor from the vehicle.

   b. Using electric motor cleaner, clean the outside of the starter motor.

   c. Check the condition of the brushes. (Simply remove the starter's inspection cover. Do not disassemble the starter unless it is to be rebuilt.) Record observations.

   d. Lube the back bushing and front shaft.

   e. Reinstall back cover.

5. Bench test the starter motor. For the proper procedure, refer to JS5-L2-UVI. Record observations. _ _ _ _

6. Following the procedure outlined below, install the starter motor. _ _ _ _

   a. Perform the procedure developed in AS1-L2-UVI.

   b. Lower the vehicle.

   c. Connect the negative battery cable.

   d. Check operation of the starter motor. Record observations.

Average of above evaluations* _ _ _ _

(*This average is a partial evaluation for Competency F2. Final evaluation For F2 will be made at the end of JS2-L2-UVI.)

MODULE: ELECTRICAL SYSTEMS

DIAGNOSING AND REPAIRING A STARTER CIRCUIT COMPONENTS

Equipment:

Hand tools
Ohmmeter
Test light
VAT
Selected vehicle
Jumper wires
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Complete AS2-L2-UVI. ___ ___ ___ ___

3. Using the procedure developed in AS2-L2-UVI, check the operation of the following components. ___ ___ ___ ___

    a. Ignition switch

       OK ___ NOT OK ___

    b. If ignition switch is NOT OK, recommend steps to correct the problem.

    c. Neutral safety switch

       OK ___ NOT OK ___

    d. If neutral safety switch is NOT OK, recommend steps to correct the problem.

    e. Solenoid or relay

       OK ___ NOT OK ___

f. If solenoid or relay is NOT OK, recommend steps to correct the problem.

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency F2. Final evaluation for F2 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency F2 by averaging the final evaluation of JS1-L2-UVI and JS2-L2-UVI. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS1-L2-UVI	—	—	—	—
JS2-L2-UVI	—	—	—	—
Final evaluation for Competency F2	—	—	—	—

MODULE: ELECTRICAL SYSTEMS

PERFORMING A STARTER CIRCUIT VOLTAGE DROP TEST

Equipment:

Voltmeter
Serviceable vehicle
Safety glasses

Evaluation
3 2 1 N

Procedure:

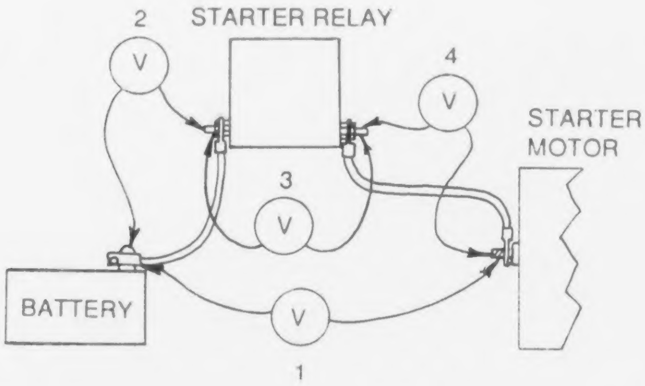
1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, measure the voltage drop across the starter power circuit. ___ ___ ___ ___

   a. Disable the ignition system to prevent the vehicle from starting.

   b. Select the 5-Volt scale on the voltmeter.

   c. Connect the voltmeter as illustrated below, so that all four power circuit voltage drop tests can be done, one at a time.



   d. Place the voltmeter in the lowest scale while cranking.

e. Crank the engine for at least 15 seconds during each of the four power circuit voltage drop tests. Record voltmeter readings for each test below.

Power circuit test _____ (1)

Battery cable test _____ (2)

Electromagnetic switch test _____ (3)

Starter cable or strap test _____ (4)

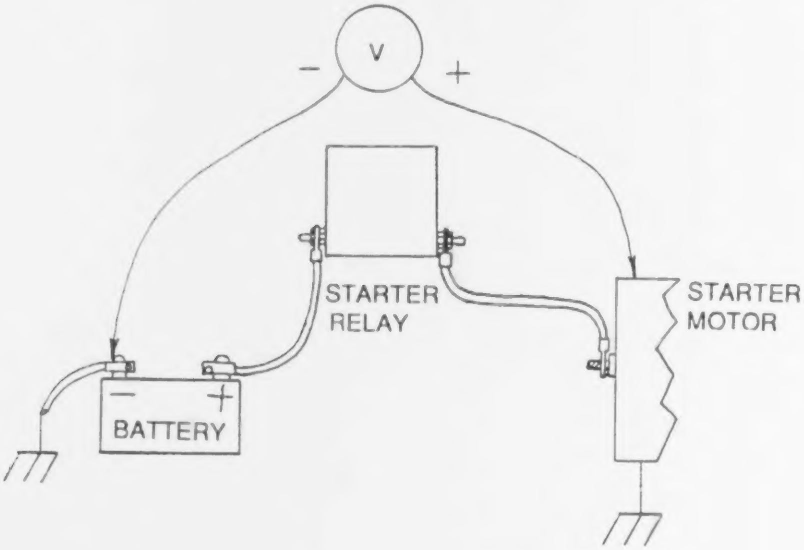
f. If any of the above readings are high, recommend steps to correct the problem.

3. Following the procedure outlined below, measure the voltage drop across the starter ground circuit. _ _ _ _

a. Disable the ignition system so the vehicle cannot start.

b. Select the low-voltage scale.

c. Connect the voltmeter as illustrated below.



d. When the voltmeter is connected, crank the engine for 15 seconds.

e. Record voltmeter reading for the voltage drop across the ground circuit.

f. If the reading is higher than allowed, recommend steps to correct the problem.

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency F1. Final evaluation for F1 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency F1 by averaging the final evaluation of JS1-L1-UVI and JS3-L2-UVI. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS1-L1-UVI	—	—	—	—
JS3-L2-UVI	—	—	—	—
Final evaluation for Competency F1	—	—	—	—

JS4-L2-UVI

MODULE: ELECTRICAL SYSTEMS

SERVICING A STARTER MOTOR

Equipment:

Hand tools
Growler
Continuity light
Electric motor cleaner
Armature lathe
Safety glasses

(NOTE: Some starter service will require the use of special tools.)

Procedure:

Evaluation
3 2 1 N

1. Complete AS3-L2-UVI. ___ ___ ___ ___

2. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

3. Remove the starter motor from the vehicle, if required. For the proper procedure, refer to JS2-L2-UVI. ___ ___ ___ ___

4. Following the procedure outlined below, clean and disassemble a starter motor and test starter motor components. ___ ___ ___ ___

    a. Clean the outside of the starter motor with a scraper and (if necessary) electric motor cleaner. Wipe or blow dry.

    b. Using the procedure developed in AS3-L2-UVI, disassemble starter motor.

    c. Using the procedure developed in AS3-L2-UVI, test the components in a starter motor. Use the following chart to record the condition of each component.

	OK	BAD
A. Check armature.		
1. Growler test		
2. Continuity (with 110V test light)		
a. Between commutator segments		
b. Commutator to armature shaft		
c. Armature shaft to armature		
B. Check poles continuity.		
1. Pole winding to case		
2. Between ends of pole windings		
C. Check armature shaft straightness.		
D. Check armature shaft front bushing.		
E. Check armature shaft rear bushing.		
F. Check starter drive.		
1. Pinion gear		
2. One way clutch		
3. Internal flute guide		
G. Check condition of flutes on armature shaft.		
H. Check brush condition.		
I. (On Ford) Check moveable pole shoe.		
J. (On Ford) Check moveable pole contact set.		
K. (On GM/Chrysler type) Check starter drive shift fork.		

5. Following the procedure outlined below, service the starter motor components and reassemble the starter motor. ____

   a. Surface the commutator on armature lathe.

      (NOTE: Refer to operating instructions on lathe before proceeding.)

b. Replace all worn or defective starter motor components. Record which components were replaced.

c. Using the procedure developed in AS3-L2-UVI, reassemble the starter motor.

6. Bench test the starter motor. For the proper procedure, refer to JS5-L2-UVI. Record observations. _ _ _ _

Free running amps ____

Minimum volts ____

a. According to this test, the starter motor is:

OK ___ NOT OK ___

b. If starter motor is not OK, explain the problem.

7. Reinstall the starter motor if required. For the proper procedure, refer to JS1-L2-UVI. _ _ _ _

8. Perform a starter current-draw test to verify that the starter motor is operating properly. For the proper procedure, refer to JS1-L1-UVI. Record observations. _ _ _ _

Average of above evaluations* _ _ _ _

(*This is a partial evaluation for Competency F3. Final evaluation for F3 will be made at the end of JS5-L2-UVI.)

JS5-L2-UVI

MODULE: ELECTRICAL SYSTEMS

BENCH TESTING A STARTER MOTOR

Equipment:

Jumper cables
Remote starter switch
VAT
Charged battery
Vise
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Use an appropriate service manual to determine the correct free-running amp draw for the starter to be serviced. Also determine the minimum voltage that the battery can reach during the starter motor bench test. Record specifications. ___ ___ ___ ___

   Free-running amps _______

   Minimum-voltage _______

3. Following the procedure outlined below, perform starter motor bench test. ___ ___ ___ ___

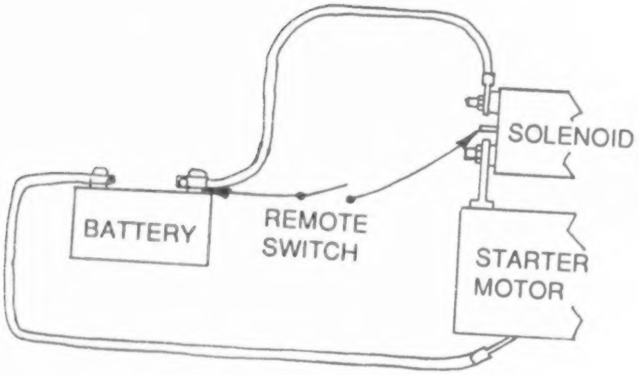
   a. Lightly clamp the starter motor in a vise.

   b. Connect the jumper leads and remote switch.

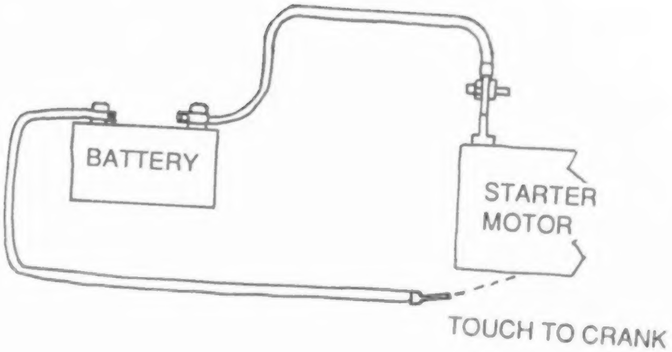
      (**CAUTION**: On Ford systems, a remote switch cannot be used to energize the starter motor. Instead, the starter motor end of the negative jumper cable should be touched to the starter motor case.)

   c. If servicing a GM vehicle, energize the starter motor by closing the remote switch. If servicing a Ford vehicle, touch the negative jumper cable to the starter motor case.

GM System

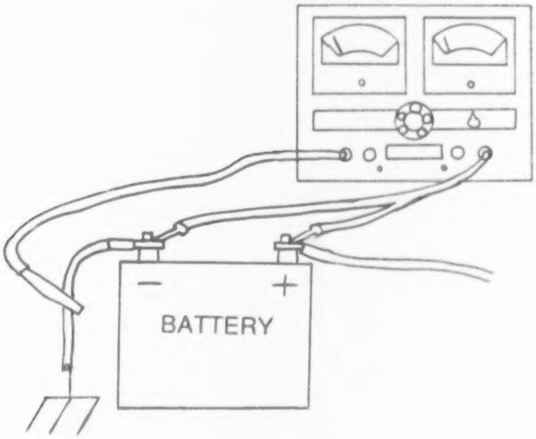

SOLENOID
BATTERY
REMOTE
SWITCH
STARTER
MOTOR

Ford System


BATTERY
STARTER
MOTOR
TOUCH TO CRANK

d. Connect the VAT as illustrated below.

(NOTE: VAT connections are the same for both GM and Ford systems.)



e. Set the ammeter to the correct scale.

f. Do not over crank the starter motor. (Crank no longer than 15-20 seconds.) Record observations.

(NOTE: Observe the meter reading while the motor is energized.)

Volts ___ Amps ___

g. According to this test, the starter motor is:

OK ___ NOT OK ___

h. If starter motor is NOT OK, recommend steps to correct the problem.

Average of above evaluations.* — — — —

(*This average is a partial evaluation for F3. Final evaluation for F3 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency F3 by averaging the final evaluation of JS4-L2-UVI and JS5-L2-UVI. Use the spaces provided below.

	Evaluation 3 2 1 N
A. Evaluation for Competency F3	
JS4-L2-UVI	— — — —
JS5-L2-UVI	— — — —
Final evaluation for Competency F3	— — — —

MODULE: ELECTRICAL SYSTEMS

UNIT VI: INSPECTING, REPAIRING, AND REPLACING STARTER COMPONENTS

UNIT VI TEST

PART I. TESTING AND DIAGNOSING THE STARTING SYSTEM

SECTION A. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 1. An inductive ammeter indirectly measures current flow by responding to the current's magnetic field.

____ 2. A relay test can be either an operational test or a voltage drop test.

____ 3. A remote starter switch serves as a substitute for the ignition switch during an operational test of the starting system.

____ 4. A single pole single throw contact switch is used to switch heavy current during a starter test.

____ 5. The starter current-draw test measures the amount of current that the starter uses to crank the engine for 15 seconds.

____ 6. The starter insulated-circuit resistance test detects any internal cable resistance and determines the amount of resistance added to the circuit as a result of increases in the magnetic fields created by the field poles.

____ 7. Testing the starter solenoid can determine the ability of the relay to create a voltage drop within high-current contacts.

____ 8. Either a jumper test or a resistance test can be performed on the starter solenoid.

SECTION B. Read each of the below statements made by technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.

____ 9. Technician I says that the voltmeter should be set at a 0-15 range during a starter current-draw test.

Technician II says that the amount of current required to crank an engine can be determined by the engine's compression, its number of cylinders, and the efficiency of its components.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 10. Technician I says that, during a starter current-draw test, the highest ammeter reading should be noted while the vehicle's engine is cranking.

Technician II says that during a starter current-draw test, the lowest ammeter reading should also be noted while the vehicle's engine is cranking.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 11. Technician I says that an ohmmeter is used to perform a starter insulated-circuit test.

Technician II says that an ammeter is used to perform a starter insulated-circuit test.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 12. Technician I says that a positive-engagement starter relay should click loudly each time it receives current.

Technician II says that a solenoid-engagement starter relay should loudly engage the starter drive and cause the starter to rotate in a free-running or cranking state.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 13. Technician I says that, during an insulated-circuit test, the way in which the voltmeter leads are connected depends on whether the system being tested has a negative or positive ground.

Technician II says that, during a resistance test of a positive-engagement relay, a voltmeter reading of "10" indicates continuity through the relay coil.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 14. Technician I says that an ammeter should not be used to perform a resistance test on a positive-engagement relay.

Technician II says that a test light should be used to perform a resistance test on a positive-engagement relay.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 15. Technician I says that an ammeter should not be used to perform a resistance test on a solenoid-shift-engagement relay.

Technician II says that a test light should not be used to perform a resistance test on a solenoid-shift-engagement relay.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 16. Technician I says that, during an ignition switch test, continuity is indicated when the ohmmeter reads "5" ohms while the switch is in the run position.

Technician II says that, during a wiring harness resistance test (ignition/start), an ohmmeter reading of less than 3 ohms indicates normal resistance.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 17. Technician I says that, during a voltage drop test of the positive battery cable, the voltmeter should be set on a low-voltage scale.

Technician II says that, during a voltage drop test of the positive battery cable, the vehicle's engine should be running.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of _____ on Part I of the Unit VI Test in order to receive an evaluation for Competency F1.)

PART II. REMOVING, CLEANING, AND INSPECTING STARTER COMPONENTS

SECTION A. **Read each of the below statements made by technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.**

____ 18. Technician I says that starter parts should be washed in solvent.

Technician II says that, during starter removal, the ground cable should remain attached to the starter.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 19. Technician I says that, during starter installation, shims should never be placed between the starter and the engine block.

Technician II says that, during starter removal, field coil connectors should remain attached to the solenoid.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 20. Technician I says that starter bushings require regular replacement.

Technician II says that the starter drive pinion gear should lock after making one complete turn in either direction.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 21. Technician I says that starter brushes should be replaced if they are worn to over half their original length.

Technician II says that starter brushes should be lightly coated with oil in order to enhance their conductivity.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 22. Technician I says that most GM starters do not use a drive pinion gear.

Technician II says that the armature commutator should be turned on a lathe if it is rough or out-of-round.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 23. Technician I says that the armature can be checked for ground by placing one lead of a test light on the armature core or shaft and the other lead on each segment of the commutator.

Technician II says that the armature can be checked for shorts by holding a hacksaw blade over the armature core and observing a voltmeter reading.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 24. Technician I says that field coils should be checked for grounds.

Technician II says that field coils should be checked for opens.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of _____ on Part II of the Unit VI Test in order to receive an evaluation for Competencies F2 and F3.)

ANSWERS TO UNIT VI TEST

1. t
2. f
3. t
4. t
5. t
6. f
7. f
8. t
9. c
10. b
11. d
12. d
13. a
14. a
15. a
16. c
17. a
18. d
19. d
20. d
21. a
22. b
23. d
24. c

MODULE: ELECTRICAL SYSTEMS

UNIT VII: CHARGING SYSTEM COMPONENTS

UNIT OBJECTIVE

After completing this unit, the student should be able to identify charging system components and the principles by which they operate. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1: I. Identify significant terms associated with charging system components and their operation (Competencies G1-G4, Unit VII Test).

II. Identify the working relationship between charging system components (Competencies G1-G4, Unit VII Test).

III. Identify the operating principles of the individual charging system components (Competencies G1-G4, Unit VII Test).

IV. Identify the characteristics of alternator construction (Competencies G1-G4, Unit VII Test).

ASE TASKS COVERED IN THIS UNIT

I. Only material that is preliminary to ASE tasks appears in this unit. No ASE tasks are covered directly.

MODULE: ELECTRICAL SYSTEMS

UNIT VII: CHARGING SYSTEM COMPONENTS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: COMPONENTS OF THE CHARGING SYSTEM AND HOW THEY FUNCTION
   a. Information outline
   b. Assignment sheets
      AS1-L1-UVII: How the Alternator Functions

E. Unit test

F. Answers to unit test

REFERENCES

Battery Council International. Battery Service Manual. Chicago: Battery Council International, 1982.

Chrysler Motors. 1988 Service Manual: Electrical, Fuel, and Emission Systems: Front Wheel Drive Car.

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DeKryger, William, J., Robert T Kovacik, and Saverio G. Bono. Auto Mechanics Theory and Service. Cincinnati: South-Western Publishing Company, 1986.

Derato, Frank. Electrical and Electronic Systems. New York: McGraw-Hill Book Company, 1986.

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Downing, Ronald. Automotive Electrical Systems and Tune-up Procedures: Instructor's Guide. Module 5 of Auto Mechanics. University of Missouri-Columbia: Instructional Materials Laboratory, 1981.

Mitchell Information Services, Inc. 1986 Domestic Cars Tune up Mechanical Service and Repair. San Diego: Mitchell Information Services, Inc., 1986.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Students should do AS1-L1-UVII before taking the UVII Test.

B. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

   1. Charging System, Principles of Operation (AM-84-410), 1984.

MODULE: ELECTRICAL SYSTEMS

UNIT VII: CHARGING SYSTEM COMPONENTS

LESSON 1: COMPONENTS OF THE CHARGING SYSTEM AND HOW THEY FUNCTION

I. Terms and definitions

A. Alternator--An electromechanical force device that converts mechanical energy into electrical energy. The alternator recharges the battery and provides current to the electrical system while the engine is running.

B. Alternating current--Current which sequentially alternates from one direction (polarity) to the opposite direction (polarity), thus creating a sine wave current output.

C. Battery potential (voltage)--Indicates the difference in chemical state of charge between the negative and positive terminals. Battery potential is measured in volts.

D. Brushes--Carbon conductors that make an electrical connection between the moving rotor slip rings and the stationary alternator housing.

E. Charge indicator--A light or gauge that detects insufficient charge rate by comparing the battery state of charge with the alternator charge output.

F. Diode--A semiconductor that allows current to flow in one direction while preventing current flow in the opposite direction.

G. Diode bridge--A group of diodes that controls the direction of the current output from the alternator. The diode bridge ensures a single direction of current from the alternator.

H. Diode trio--A diode group that sends current to the internal voltage regulator on a delcotron alternator.

I. Direct current--Current that flows in only one direction.

J. Fusible link (alternator)--A protective device that self-destructs in order to protect the charging circuit from excessive current flow.

K. Generator--An electromechanical device that produces direct current. The generator is similar in construction to a starting motor. The generator is not used on modern automobiles.

L. Internal regulator--A device that regulates voltage in order to control the alternator's charging rate. The internal regulator is located within the alternator housing.

M. Rectification--A process by which alternating current is converted to direct current. The diode bridge achieves rectification.

N. Rotor--A component that rotates within the alternator's stator windings, thereby breaking the magnetic fields across the windings. This breaking of magnetic fields induces current in the stator.

O. Slip rings--Rotating contact surface on which the brushes ride. The current that flows through the slip rings is used by the rotor to produce a magnetic field.

P. Stator windings--Current-producing windings that surround the rotor. The stator usually consists of three distinctive sets of windings called phases, which produce alternating current.

Q. Voltage regulator--Device that regulates alternator or generator rate of charge by measuring battery potential difference (voltage).

II. The working relationship between charging system components

A. The battery provides a current source for the starter motor. The battery also supplies current to the vehicle's electrical system when alternator output is low (when the engine is idling, for example).

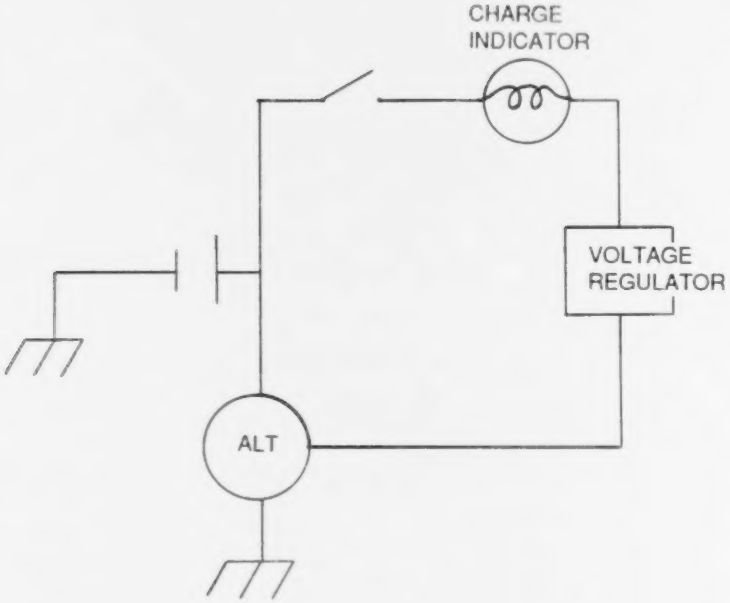
B. The alternator

1. The alternator uses a small amount of current to produce an internal magnetic field. The mechanical force of the engine causes this field to rotate within a group of windings (conductors) called the stator.

2. The magnetic field (along with the mechanical energy produced by the engine) supplies the vehicle's electrical system with current and maintains the battery at full charge.

3. The rate of alternator current output is controlled by varying the strength of the alternator's magnetic field in the rotor.

C. The charge indicator compares the alternator's current output to the requirements of the vehicle's electrical system. The indicator will light a warning lamp or move a gauge needle to signal a "No Charge" or "Low Charge" condition.



D. Charging system current path (when engine is not running)

1. The battery provides current to the electrical system.

2. The voltage regulator is off and, therefore, prevents current flow to the rotor (the device that produces a magnetic field inside the alternator).

3. The alternator is idle (not turning).

E. Charging system current path when engine is running

1. Mechanical energy is delivered to the drive pulley on the alternator.

2. The voltage regulator allows current to pass to the rotor--(the device that produces a magnetic field inside the alternator).

3. Mechanical energy forces the magnetic field to break across the internal conductors, causing the conductors to generate current.

4. The current generated by the internal conductors flows into the vehicle's electrical system. Any current not consumed by the electrical system is used to recharge the battery.

5. As the engine runs, the battery will recover a full charge, at which time the voltage regulator will reduce the current flow to the rotor and thus reduce the output of the alternator.

III. The operation of individual charging system components

A. Alternator

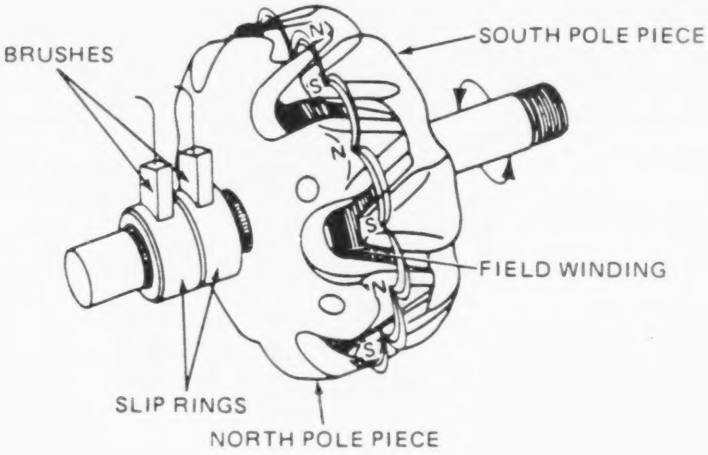
1. The alternator functions according to the principles of electromagnetism. One principle of electromagnetism states that current flowing through a conductor produces a magnetic field around that conductor. The magnetic field can be strengthened or weakened by any of the three methods listed below.

   a. Wrapping the conductor into a coil

   b. Increasing the rate of current flow through the coil by increasing the circuit's voltage or lowering the conductor's resistance

   c. Placing an iron core near the conductor (coil)

2. The rotor of an alternator makes use of the principles of electromagnetism as well as the methods (listed above) for increasing the magnetic field around a conductor. If current passes into one of the rotor's slip rings, continues through the windings, and then moves out the other slip ring to ground, a strong magnetic field will be established between the iron fingers of the rotor.



3. Another electromagnetic principle states that, if a magnetic field passes across a conductor, a current will be induced in that conductor. Any of the procedures listed below will increase the amount of the current produced in a conductor by causing a magnetic field to pass across the conductor.

   a. Wrapping the conductor into a coil so that more of the conductor is exposed to the magnetic field

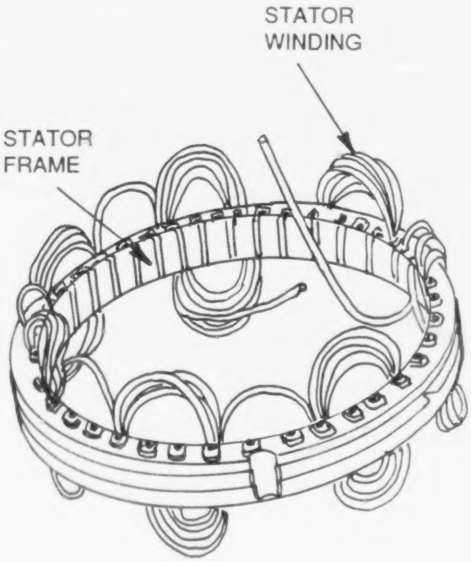
   b. Increasing the strength of the magnetic field

(NOTE: The strength of the magnetic field can be increased by performing any of the procedures described in items 1a-1c above.)

c. Increasing the number of events (the number of times the magnetic field is broken) or increasing the number of conductors

d. Increasing the number of conductors wrapped in the coil

e. Placing an iron core near the conductor



4. The stator is a conductor through which a magnetic field rotates.

   a. In order to enhance the alternator's ability to produce current, the stator uses three sets of conductors wound through a stationary iron ring in the alternator housing.

   b. The three sets of windings may be wired in a wye or delta arrangement.

   c. The rotor (a magnetic field producing device) rotates within the stator's iron ring, passing the magnetic field across the stator's conductors and thus inducing current flow (in the stator).

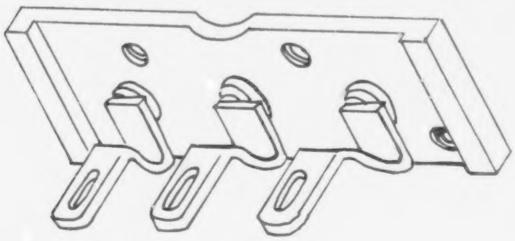
   d. The rotor's magnetic field reverses polarity from one finger of the iron core to the next; therefore, the direction of current induced in the stator will alternate as the polarity of the rotor fingers passes the various stator windings.

   (NOTE: Current that alternates its direction is referred to as alternating current or AC.)

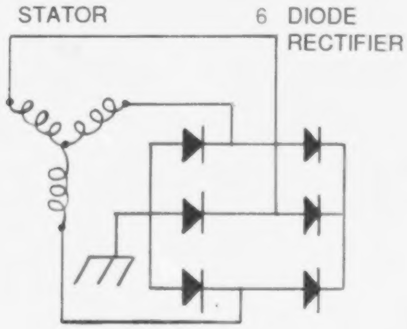
e. Neither the vehicle's electrical system nor the battery can use alternating current (AC). AC must, therefore, be rectified to direct current (DC).

5. A diode (a type of semiconductor) allows current to flow in one direction only. When placed in series with the stator windings, the diode will rectify alternating current to direct current.

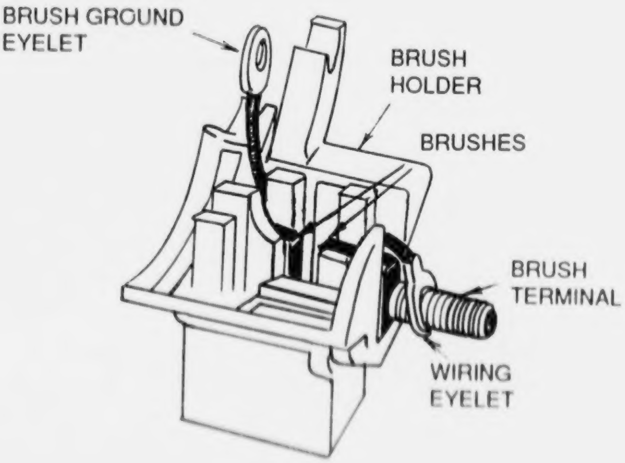
   a. Two diodes are needed for each stator winding. Since an alternator has three windings, a total of six diodes are required.



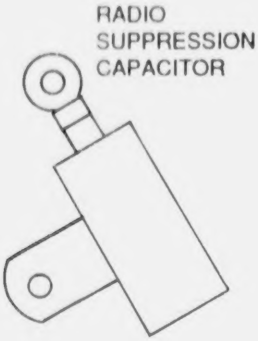
   b. Sometimes the diodes are grouped into a single unit called a diode bridge.



6. Carbon brushes provide a current path from the voltage regulator through the rotor to ground. The brushes are mounted in an insulated holder; spring tensioners push the brushes against the slip rings.


BRUSH GROUND EYELET
BRUSH HOLDER
BRUSHES
BRUSH TERMINAL
WIRING EYELET

7. A radio suppression capacitor, placed in parallel with the stator windings, suppresses any radio static caused by the alternator.


RADIO SUPPRESSION CAPACITOR

B. Voltage regulator

1. Functions of the voltage regulator

   a. The voltage regulator maintains an appropriate level of charge in the battery.

   b. The voltage regulator limits system voltage to between 13.5 and 14.8 volts.

c. The voltage regulator controls the charging rate of the alternator by controlling the current flowing to the rotor and by varying the strength of the magnetic field within the rotor.

d. To prevent battery discharge, the voltage regulator turns off the rotor's magnetic field when the engine is not running.

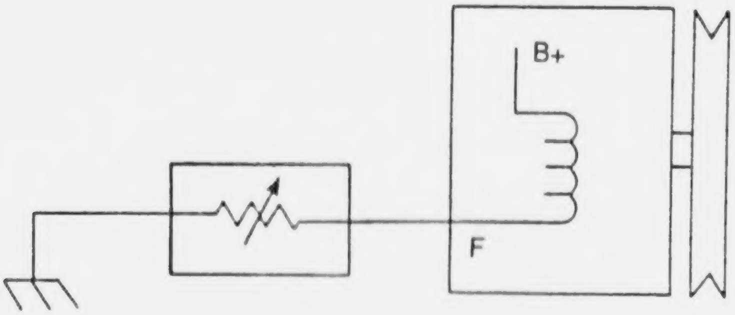
e. The voltage regulator prevents the rotor from creating a magnetic field until the engine is running at sufficient speed.

2. Manufacturers use one of three circuit arrangements to wire the voltage regulator to the alternator's rotor circuit: the A circuit, the B circuit, and the isolated A or B circuit. All three are discussed below.

3. Arrangement of the voltage regulator with an A circuit

   a. In an A circuit arrangement, battery current enters and exists the field windings through the insulated brushes.

   b. The voltage regulator selects a varying ground potential, regulating the rate of current flow through the field windings and changing the strength of the magnetic field in accordance with battery state of charge.

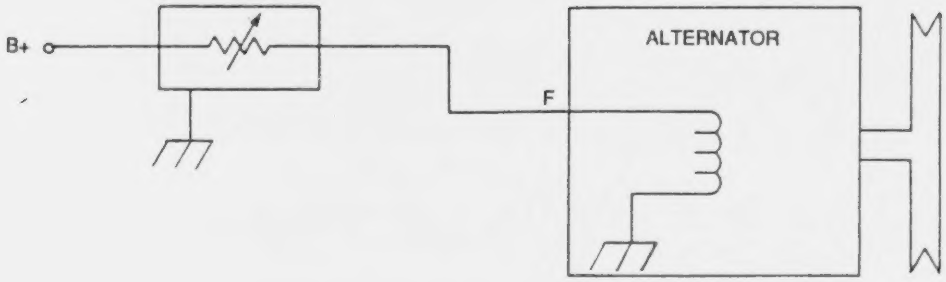


4. Arrangement of the voltage regulator with a B circuit

   a. In a B circuit arrangement, the battery provides current to the regulator.

   b. The voltage regulator varies the amount of current passing from the regulator to the alternator field. (The current enters and exits the rotor through the brushes.)

   c. The amount of current is determined by the battery's state of charge.

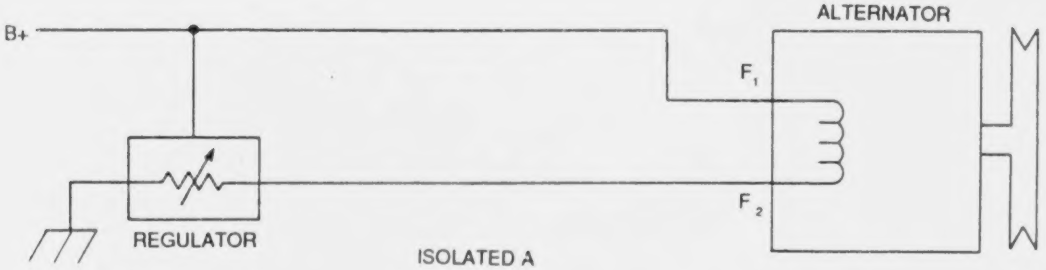


5. Arrangement of the voltage regulator with an isolated A or B circuit

   a. In the isolated A or B circuit arrangement, ground potential will be achieved at a location away from the alternator.

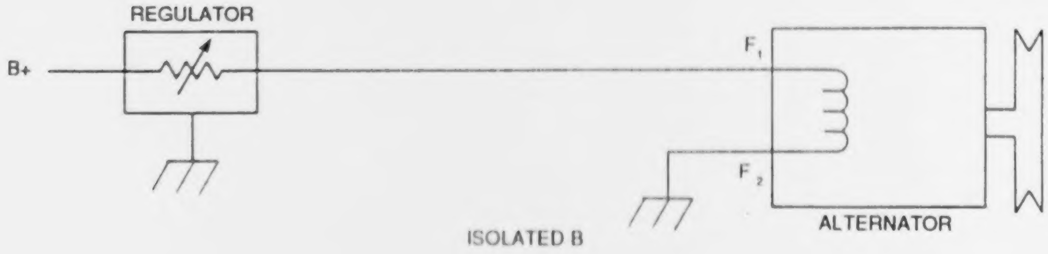
   b. This specialized arrangement is found on some late model, computer-controlled cars.

   c. In the isolated A circuit, one of the alternator's field terminals is connected to battery positive and is a source for field current in the rotor. Current passes through the other alternator field terminal to the voltage regulator and then on to ground.



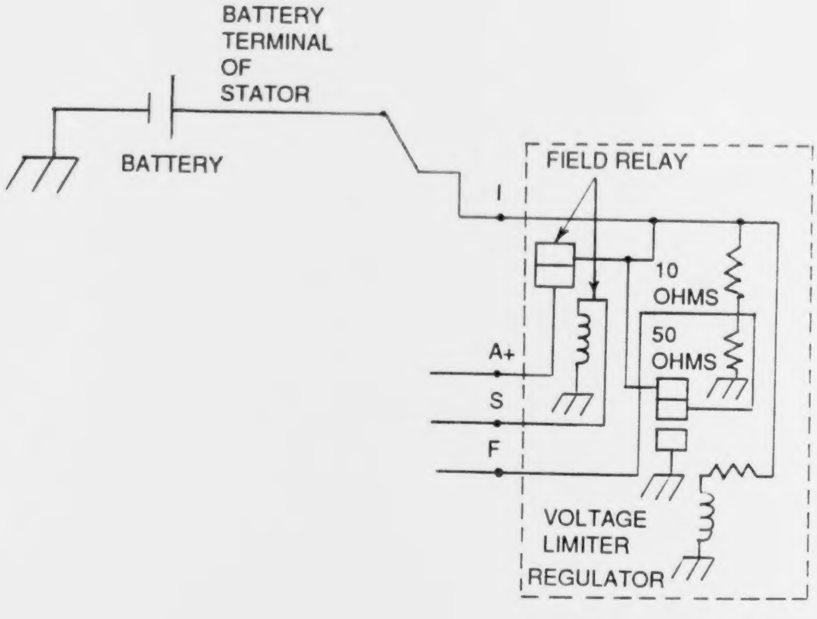
ISOLATED A

d. In the isolated B circuit, current travels from the battery positive to the voltage regulator. One of the alternator's field terminals is connected to the voltage regulator and is a source for field current in the rotor. Current passes through the other alternator field terminal and then on to ground at a point away from the alternator.

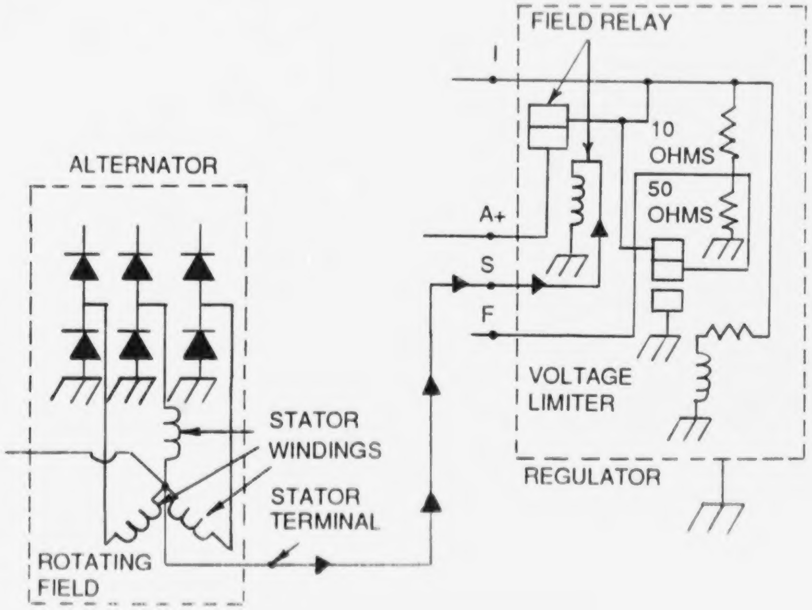

REGULATOR
B+
F_1
F_2
ALTERNATOR
ISOLATED B

7. Circuit arrangement of the stator output terminal

a. The stator output terminal is connected to the field relay of the voltage regulator. This circuit arrangement delays the full fielding of the field circuit until the engine is running fast enough to prevent stalling. On some vehicles, the stator output signal is also used to power the choke heater.


BATTERY
TERMINAL
OF
STATOR
BATTERY
FIELD RELAY
I
10
OHMS
50
OHMS
A+
S
F
VOLTAGE
LIMITER
REGULATOR

b. By sensing the output of the stator, the regulator will fully engage the field circuit when the stator output reaches a specified point in voltage.



FIELD RELAY
I
10 OHMS
50 OHMS
A+
S
F
VOLTAGE LIMITER
REGULATOR
ALTERNATOR
STATOR WINDINGS
STATOR TERMINAL
ROTATING FIELD

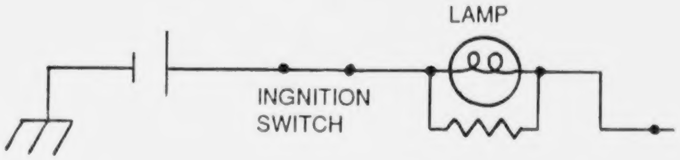
8. Circuit arrangement of the charge indicator light terminal

a. The charge indicator light terminal is a current output terminal on the voltage regulator.

b. On most vehicles, the charge indicator light is wired in parallel to a resistor. If the bulb fails, a current path is provided through the resistor.

c. When the engine is not running or when the alternator output is low, battery current will flow through the filament (on the way to the rotor) causing the filament to glow.

d. When alternator output is high enough (equal to battery voltage), alternator current from the charge indicator light terminal on the voltage regulator opposes battery current, causing the light to go out.


LAMP
INGNITION SWITCH

9. Some charging circuits will have an isolated ground circuit between the voltage regulator and the alternator.

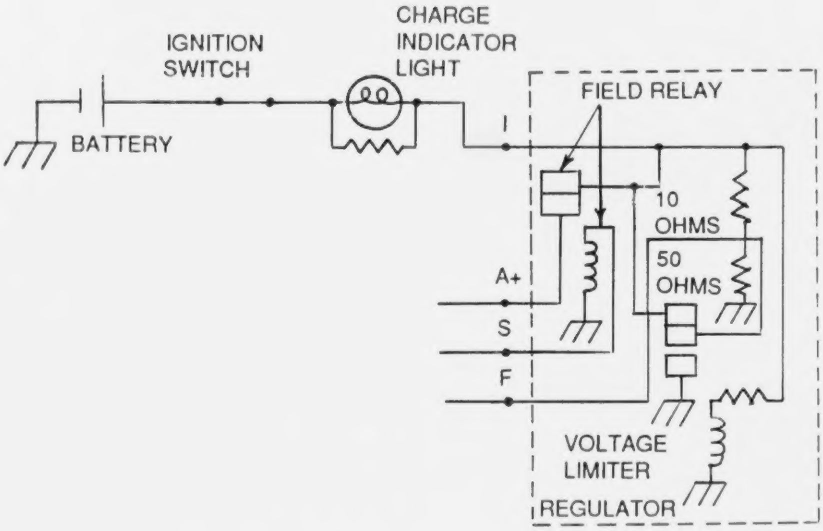
C. Charge indicator circuits

1. There are three types of charge indicators: the charge indicator light, the ammeter, and the voltmeter. All three types of charge indicator circuits are described below.

2. Charge indicator light

a. In a charge indicator light circuit, an output from the regulator is balanced against a signal from the ignition switch.

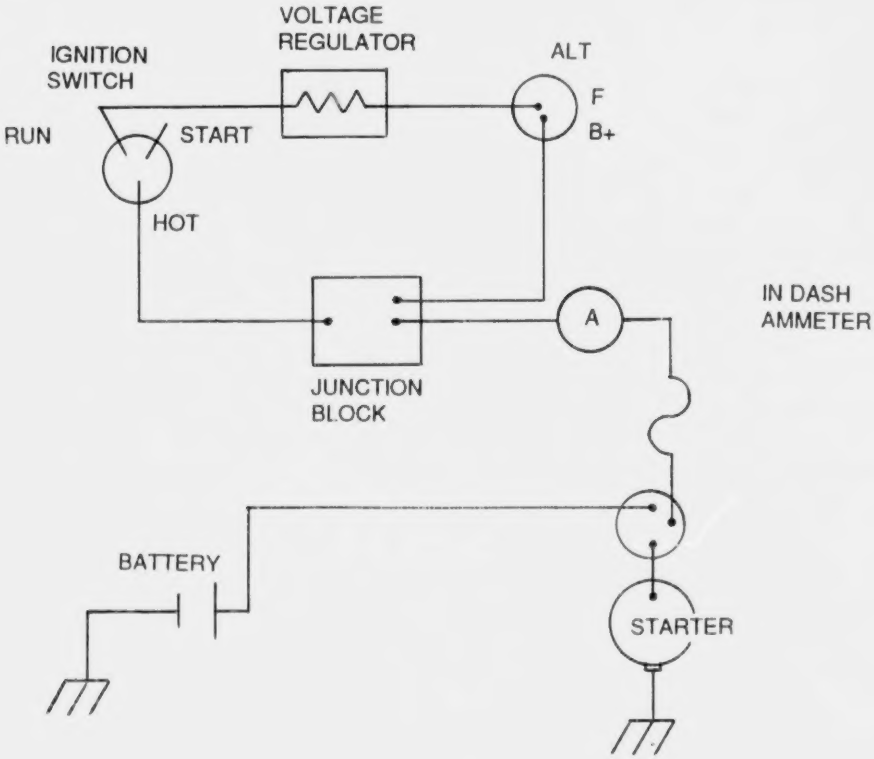
b. When the alternator output is within 1 volt of battery voltage, the light will not glow. If alternator output should fall below battery voltage, the light will glow.


IGNITION SWITCH
CHARGE INDICATOR LIGHT
BATTERY
FIELD RELAY
I
10 OHMS
50 OHMS
A+
S
F
VOLTAGE LIMITER
REGULATOR

3. Ammeter indicator circuit

a. A shunt reading ammeter is installed in series to the battery between the alternator output terminal and the load circuit. The ammeter records the amount of current flow in the circuit.

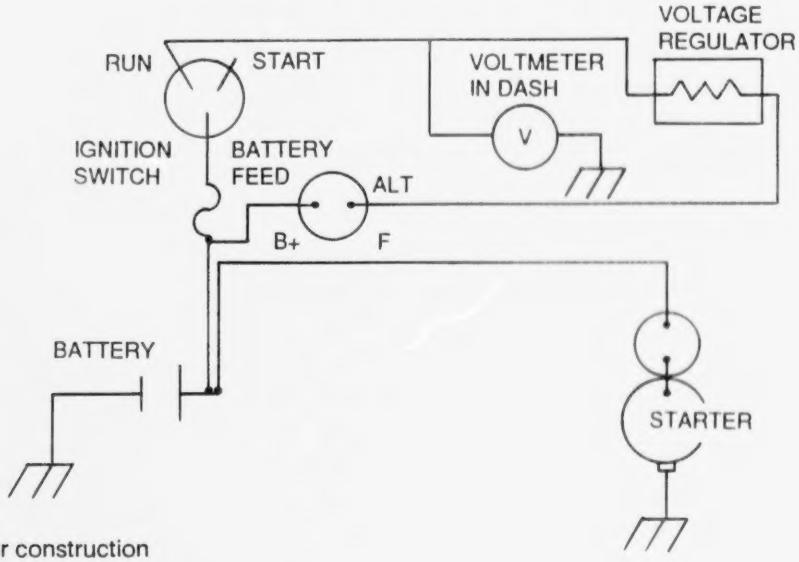
b. If current is being forced into the battery by the alternator, the gauge will indicate a (+) or charge condition. If the current is passing from the battery into the system, the ammeter will indicate a (-) or discharge condition.


VOLTAGE REGULATOR
IGNITION SWITCH
ALT
F
B+
RUN
START
HOT
A
IN DASH AMMETER
JUNCTION BLOCK
BATTERY
STARTER

4. Voltmeter indicator circuit arrangement

   a. A voltmeter is wired in parallel to the alternator output and system load. The voltmeter operates on the premise that, as the alternator charges the battery, the battery's voltage will increase proportionately.

   b. A battery that is above 12.5 volts will indicate a full charge. A battery that is below 12.5 volts will indicate an inadequate charge.


VOLTAGE REGULATOR
RUN
START
VOLTMETER IN DASH
V
IGNITION SWITCH
BATTERY FEED
ALT
B+
F
BATTERY
STARTER

IV. Alternator construction

- A. Housing construction
  - 1. Mounting
  - 2. Bearings
  - 3. Through bolts
- B. Stator construction
  - 1. Windings
    - a. Wye wound
    - b. Delta wound
  - 2. Laminated iron core
  - 3. Through bolt holes
- C. Rotor construction
  - 1. Stamped iron core

    2. Windings
    3. Slip rings
    4. Bearing surface
    5. Cooling fan mount

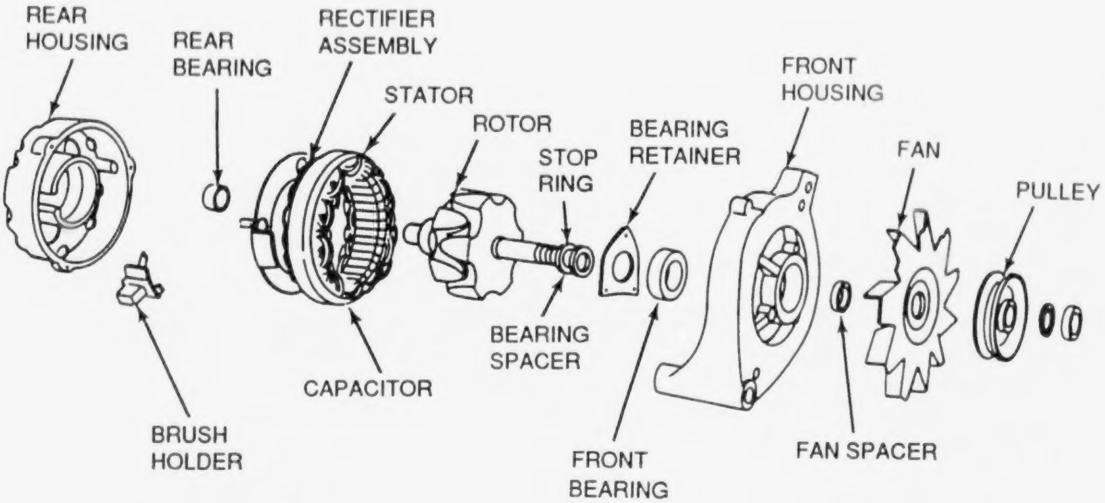
D. Diode bridge construction

    1. Positive and negative plates
    2. Insulated washers
    3. Terminal mounts

E. The diode trio delivers positive voltage to the internally regulated alternator (on GM automobiles).

F. Internal regulator (if applicable)

    1. Function (same as external regulator)
    2. Return springs
    3. Brushes and leads


REAR HOUSING
REAR BEARING
RECTIFIER ASSEMBLY
STATOR
ROTOR
STOP RING
BEARING RETAINER
FRONT HOUSING
FAN
PULLEY
BRUSH HOLDER
CAPACITOR
BEARING SPACER
FRONT BEARING
FAN SPACER

AS1-L1-UVII

MODULE: ELECTRICAL SYSTEMS

HOW THE ALTERNATOR FUNCTIONS

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. An alternator converts mechanical energy into what kind of energy?

2. Explain the function of the diodes in an alternator.

3. Explain why the alternator indicator light goes out when the alternator is producing electrical current.

4. List the three alternator components that function together to produce electrical current.

MODULE: ELECTRICAL SYSTEMS

HOW THE ALTERNATOR FUNCTIONS

(ANSWER SHEET)

1. Electrical energy.
2. The diodes rectify alternating current to direct current.
3. The output voltage applied to both sides of the indicator light is equal; therefore, current cannot flow through the light.
4. Stator, rotor, and diodes

MODULE: ELECTRICAL SYSTEMS

UNIT VII: CHARGING SYSTEM COMPONENTS

UNIT VII TEST

SECTION A. **Match the terms below with their appropriate definitions.**

____ 1. An electromagnetical force device that converts mechanical energy into electrical energy.

____ 2. Current-producing windings that surround the rotor.

____ 3. An electromagnetic device that produces direct current.

____ 4. A device that rotates within the alternator stator windings and produces a magnetic field.

____ 5. A rotating contact surface for the brushes.

____ 6. A type of semiconductor that allows current to flow with resistance in one direction (polarity) but prevents current flow in the opposite direction.

____ 7. Carbon conductors used to make an electrical connection between the moving rotor slip rings and the stationary alternator housing.

a. Alternator

b. Brushes

c. Diode

d. Fusible link

e. Generator

ab. Rotor

ac. Slip rings

ad. Stator windings

SECTION B. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 8. Alternating current maintains constant polarity.

____ 9. Direct current creates a sine wave current output.

____ 10. An important function of the diode bridge is to ensure that the alternator produces alternating current.

____ 11. A diode trio sends current to the internal voltage regulator on a delcotron alternator.

____ 12. The battery provides current to the vehicle's electrical system while engine is idling.

____ 13. A vehicle's battery is recharged during periods of normal alternator output.

____ 14. The rate of alternator current output can be controlled by varying the battery's state of charge.

____ 15. The charge indicator compares the current output of the alternator to system voltage.

____ 16. The alternator is idle when the engine is not running.

____ 17. While the engine is running, the voltage regulator controls the current flow in the rotor.

____ 18. After the alternator has recharged the battery, the voltage regulator will increase the current flow to the alternator's rotor and thus increasing the alternator's current output.

____ 19. One principle of electromagnetism states that current flowing through a conductor weakens the magnetic field surrounding that conductor.

____ 20. One principle of electromagnetism states that, if a magnetic field is broken across a conductor, current will be induced in that conductor.

____ 21. The stator insulates the rotor.

____ 22. Two diodes are required for each of the stator windings in the alternator.

____ 23. Aluminum bolts hold carbon brushes in an insulated holder.

____ 24. The charge indicator light comes on when there is no current flow within the charging system.

____ 25. Rectification is the process by which alternating current is converted into direct current.

Section C. Select the best answer from the five choices listed.

____ 26. According to one principle of electromagnetism, the strength of an electrical field around a conductor can be increased by

a. wrapping the conductor into a coil.
b. raising the voltage of the current which is flowing through the conductor.
c. placing an iron core near the conductor.
d. all of the above.
e. none of the above.

____ 27. If current passes into one slip ring of the rotor, continues through the windings, and then moves out of the other slip ring to ground,

a. the magnetic field between the iron fingers of the rotor will be broken.
b. the iron finger of the rotor will self-destruct.
c. the iron fingers of the rotor will then create an open in the alternator.
d. a warning device will be activated.
e. a strong magnetic field will be established between the iron fingers of the rotor.

____ 28. Because the magnetic field reverses polarity from one finger of the rotor's iron core to the next, the direction of the current induced in the stator will alternate from positive to negative and create

a. a momentary open in the system.
b. a momentary voltage surge.
c. an AC output.
d. all of the above.
e. none of the above.

____ 29. Sometimes diodes are grouped into a single unit called

a. a diode bridge.
b. an internalized regulator.
c. a fusible link tripod.
d. a diode conglomerate.
e. a condensation unit.

____ 30. The voltage regulator limits the charging system to between

a. 5 and 6 volts.
b. 13.5 and 14.5 volts.
c. 7.5 and 10 volts.
d. 3 and 5 volts.
e. none of the above.

____ 31. Within the charging system, the voltage regulator controls the charging rate of the alternator by controlling the current to the rotor and thus

a. varying the strength of the magnetic field within the rotor.
b. eliminating the magnetic field within the rotor.
c. reversing the flow of current in the rotor.
d. preventing rectification from occurring in the rotor.
e. preventing unnecessary wear of the rotor.

____ 32. The three basic field terminal circuit arrangements in voltage regulators are

a. the A circuit.
b. the B circuit.
c. the A or B circuit.
d. all of the above.
e. none of the above.

____ 33. Some voltage regulators within the charging system have a grounding terminal from the regulator to the

a. battery.
b. car body.
c. engine block.
d. starter motor.
e. alternator.

____ 34. The component that records the passage and direction of current flow in the charging system is the

a. charge indicator light.
b. voltmeter.
c. ammeter.
d. ohmmeter.
e. carbon pile.

____ 35. Output from the regulator is balanced against a switch-controlled output from the ignition switch. This is a description of

a. the charge indicator light circuit.
b. the ammeter indicator circuit.
c. the voltmeter indicator circuit.
d. all of the above.
e. none of the above.

(NOTE: The student must obtain a minimum score of _____ on the Unit VII Test in order to receive an evaluation for Competencies G1-G4.)

ANSWERS TO UNIT VII TEST

1. a
2. ad
3. e
4. ab
5. ac
6. c
7. b
8. f
9. f
10. f
11. t
12. t
13. t
14. f
15. t
16. t
17. t
18. f
19. f
20. t
21. f
22. t
23. f
24. t
25. t
26. d
27. e
28. c
29. b
30. b
31. a
32. d
33. e
34. c
35. a

MODULE: ELECTRICAL SYSTEMS

UNIT VIII: CHARGING SYSTEM DIAGNOSIS AND REPAIR

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose and test a charging system. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1. I. Identify terms and definitions associated with charging system test procedures (Competencies G1 and G4, Unit VIII Test).

II. Identify procedures for inspecting and testing charging system components (Competency G1, Unit VIII Test).

III. Demonstrate the ability to:

- a. Perform preliminary tests of the charging system and repair or replace charging system components (Competencies G1 and G4, JS1-L1-UVIII).
- b. Perform an alternator output test (Competency G1, JS2-L1-UVIII).
- c. Perform an alternator full-field test (Competency G1, JS3-L1-UVIII).
- d. Perform a voltage regulator cutout test (Competency G1, JS4-L1-UVIII).
- e. Perform a charging circuit resistance test (Competency G1, JS5-L1-UVIII).
- f. Determine charging system requirements (Competency G1, JS6-L1-UVIII).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks F027-F032, F034, and F035. The job sheets can be adapted to cover ASE task F033.

MODULE: ELECTRICAL SYSTEMS

UNIT VIII: CHARGING SYSTEM DIAGNOSIS AND REPAIR

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: TESTING, INSPECTING AND REPAIRING THE CHARGING SYSTEM

    a. Information outline

    b. Job sheets

      JS1-L1-UVIII: Preliminary Test of the Charging System
      JS2-L1-UVIII: Alternator Output Test
      JS3-L1-UVIII: Alternator Full-Field Test
      JS4-L1-UVIII: Voltage Regulator Cutout Test
      JS5-L1-UVIII: Charging Circuit Resistance Test
      JS6-L1-UVIII: Determining Charging System Requirements

E. Unit test

F. Answers to unit test

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Derato, Frank. Electrical and Electronic Systems: Shop Manual. New York: McGraw-Hill Book Company, 1986.

Downing, Ronald. Automotive Electrical Systems and Tune-up Procedures: Instructor's Guide. Module 5 of Auto Mechanics. University of Missouri-Columbia: Instructional Materials Laboratory, 1981.

Mitchell Information Services, Inc. 1986 Domestic Cars Tune up Mechanical Service and Repair. San Diego: Mitchell Information Services, Inc., 1986.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. If the student performs JS1-L1-UVIII immediately before JS2-L1-UVIII, he or she may skip item 2 of JS2-L1-UVIII.

2. If the student performs JS2-L1-UVIII immediately before JS6-L1-UVIII, he or she may skip item 2 of JS6-L1-UVIII.

B. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

1. Charging System Tests (AM-84-420), 1984.

MODULE: ELECTRICAL SYSTEMS

UNIT VIII: CHARGING SYSTEM DIAGNOSIS AND REPAIR

LESSON 1: TESTING, INSPECTING, AND REPAIRING THE CHARGING SYSTEM

I. Terms and definitions

   A. "A" circuit--An alternator field control that grounds the field circuit in the voltage regulator.

   B. "B" circuit--An alternator field control that grounds the field circuit inside the alternator.

   C Belt tension gauge--A device for measuring the preloaded tension on a drive belt. The belt tension gauge measures in pounds of tension.

   D. Carbon pile--A stack of carbon plates that produce a variable current load on the battery or charging system.

   E. Full-fielding--A method of supplying maximum current flow through the field circuit of the alternator. Full-fielding is used to test maximum alternator output without voltage regulation.

   F. Grounded circuit resistance--A measure of the resistance in the grounded portion of the charging circuit. Ground circuit resistance is measured by the amount of voltage drop in the circuit.

   G. Insulated circuit resistance--A measure of the resistance in the insulated portion of the charging circuit. Insulated circuit resistance is measured by the amount of voltage drop in the circuit.

   H. Isolated A or B circuit--An alternator field control. The isolated A or B circuit does not ground the field circuit in the alternator or the regulator, but rather in a remote site.

   I. Multirib belt--A flat drive belt with multiple drive ribs. The multirib belt is driven by a multiple V pulley.

   J. Regulator bypass--A method of bypassing the field control portion of the voltage regulator so that the field can receive maximum alternator output. A regulator bypass is referred to as a full-field test.

   K. Serpentine belt--A flat multirib belt that weaves around the driven and drive pulleys and runs all engine accessories.

   L. Shunt ammeter--An ammeter that uses an internal shunt bar to measure current flow in amperes.

   M. Temperature-compensated regulator--A voltage regulator that uses either a mechanical or semi-conductor (thermistor) device to alter regulation on the basis of ambient temperature.

N. V-Belt--A V-shaped belt that runs in V pulleys and drives engine accessories.

O. VAT or BST--A combination test instrument that houses a voltmeter, a shunt ammeter, and a carbon pile.

P. Voltage drop--A measure of the circuit's internal resistance. A voltage drop results from a voltage change across the circuit.

Q. Voltage regulator cutout point--A predetermined level of battery charge (measured in volts). When the battery's charge reaches the voltage regulator cutout point, the regulator will automatically reduce the charging rate of the alternator by reducing current flow to the alternator field circuit.

R. Voltmeter--A meter that measures the charge pressure (force) in a circuit.

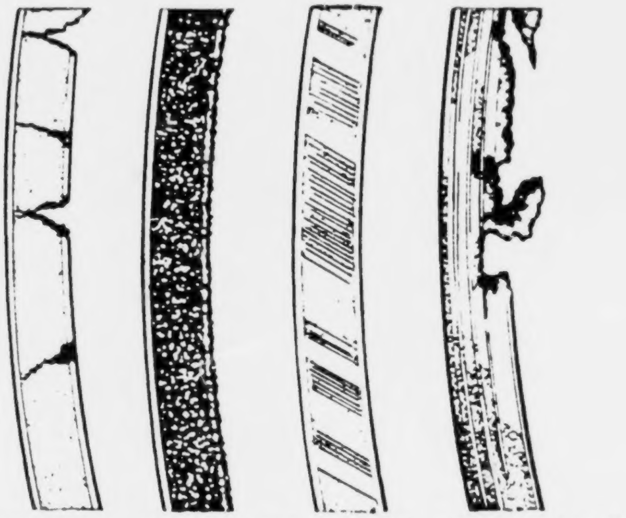
II. Inspecting and testing the charging system and its components

A. Inspecting charging system belts

1. The V-Belt

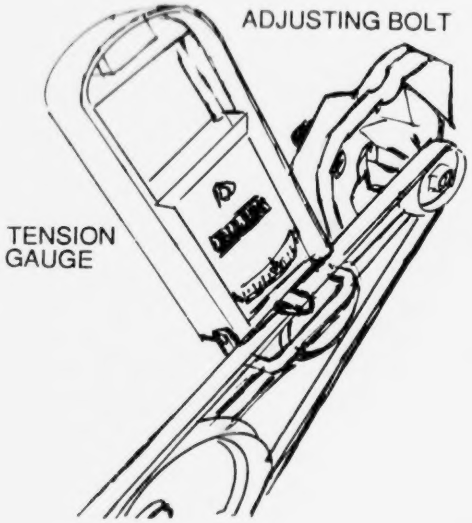
a. The V-belt is moved by friction created between the two sides of the drive pulley. Tension on the belt concentrates the friction on the belt's surface. (Belt tension is adjustable.)

b. Check the belt for cracks and glazing and make sure the belt is not oil-soaked or torn. Also make sure that excessive wear has not caused the belt's inside face to bottom in the pulley. Replace worn or faulty belts.

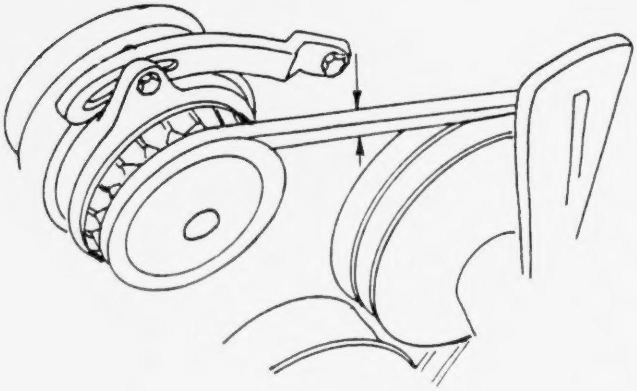


CRACKED OIL-SOAKED GLAZED TORN OR SPLIT

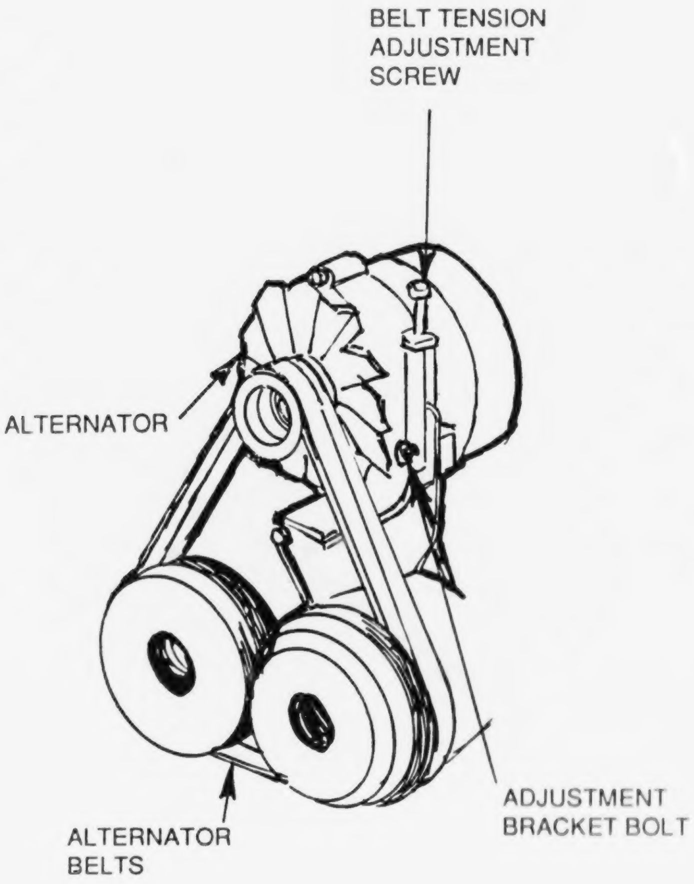
c. On some vehicles, belt tension must be measured with a tension gauge. Follow the procedures provided by the manufacturer of the gauge. Compare the readings to service manual specifications.



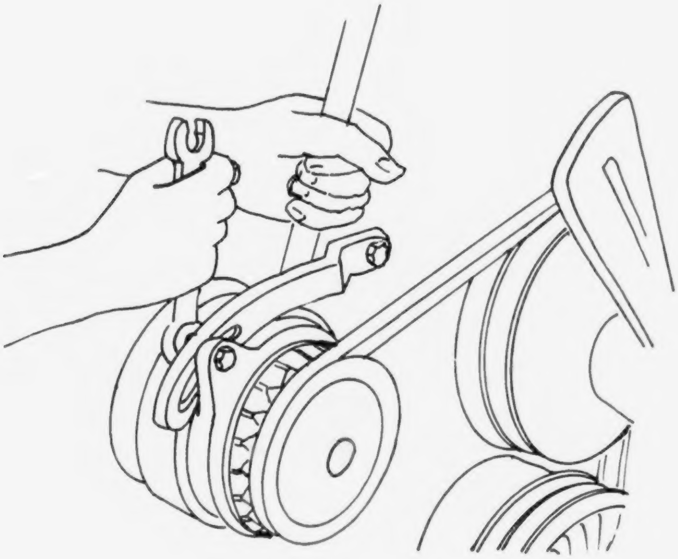
d. On some vehicles, belt tension is measured by determining the amount of up-and-down flex in the middle of the longest belt span. Normally 1/2" to 3/4" of movement is desirable.



e. Some vehicles have an adjusting or tensioning screw to change V-belt tension.


BELT TENSION ADJUSTMENT SCREW
ALTERNATOR
ADJUSTMENT BRACKET BOLT
ALTERNATOR BELTS

f. Some vehicles have slotted grooves for V-belt adjustment.



2. Multirib belt

   a. The multirib belt is essentially a group of miniature V-belts bound together to form a single flat belt. The multirib belt requires high tension to maintain efficiency.

   b. If the multirib belt is cracked, glazed, frayed, dangerously thin, or oil-soaked, it should be replaced.

   c. When checking and adjusting the tension of the multirib belt, use the same procedure as for the V-belt.

3. Serpentine belt

   a. The serpentine is a flat multirib belt that runs around or under all drive and driven pulleys. The serpentine belt requires very high tension for maximum efficiency. Special care must be taken to observe proper routing when replacing the serpentine belt.

   b. When inspecting the serpentine belt, use the same procedure as for the multirib belt.

   c. The serpentine belt often uses an idler pulley, which also functions as a tensioner.

B. Alternator output test

1. General description of the alternator output test

    a. The voltage regulator measures a battery's voltage to determine its state of charge. The test for measuring maximum regulated alternator output must also be based on battery voltage.

    b. During the alternator output test, a carbon pile is used to reduce battery voltage while the engine is running at the manufacturer's specified RPM (usually 1700-2200 RPM).

    c. The voltage regulator senses the decrease in battery voltage and responds by increasing the field current in the alternator. The alternator will then increase its output.

    d. Increasing the drain on the battery will cause the alternator and regulator to achieve their maximum output.

2. Equipment needed for the alternator output test

    a. A voltmeter capable of measuring at least 18 volts

    b. Either an inductive or shunt ammeter with a 75-100 amp range

    (NOTE: If the test is performed with a shunt ammeter, a heavy-duty switch will be needed to open the battery circuit so the ammeter can be placed in series. Observe polarity when clamping the inductive ammeter cable.)

    c. A carbon pile

    (NOTE: The volt amps tester [VAT or BST] is a single unit that includes all of the meters needed to test the alternator.)

3. Hooking up equipment for the alternator output test

    a. Hook the voltmeter in parallel to the battery. Be sure to observe correct polarity.

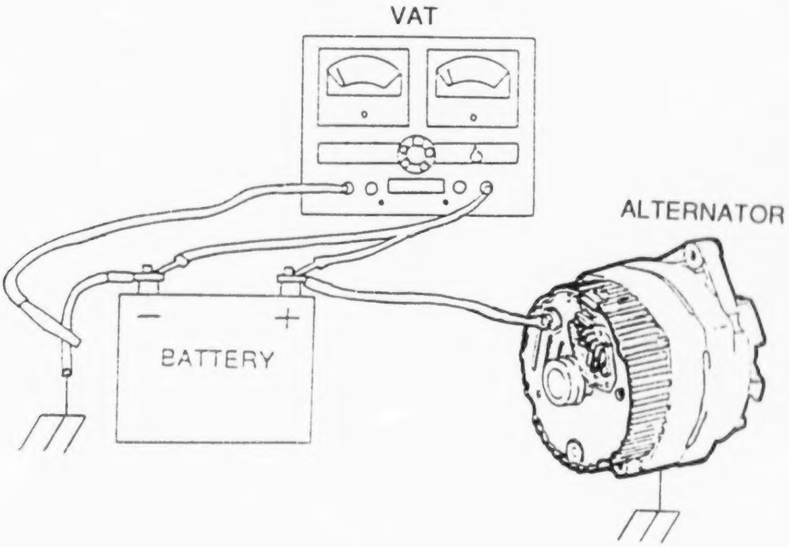
    b. If shunt ammeter is used, connect switch in series to the ground post of the battery. Connect ammeter leads on each end of the switch before starting engine.

    (**CAUTION:** Shunt ammeters are not recommended for use on vehicles equipped with computers.)

    c. If an inductive ammeter is used, attach its inductive clamp to the negative battery cable.

d. Connect carbon pile in parallel to the battery.

(NOTE: A tachometer may be used in this test if desired; however, an approximate measure of the engine's RPM is usually adequate.)



4. Procedure for the alternator output test

a. Connect all meters.

b. Check drive belt for wear and looseness.

c. Start engine and run it at specified RPM.

d. Begin to twist carbon pile knob while observing ammeter and voltmeter readings.

e. Adjust carbon pile to obtain the highest current reading on the ammeter.

f. Use a voltmeter to ensure that the carbon pile does not reduce voltage to less than 10 volts.

g. If output reading is below specification, perform alternator output test (full-field test).

C. Alternator full-field test

1. General description of alternator full-field test

   a. The alternator output test will detect both the failure of the alternator to charge and the failure of the voltage regulator to supply sufficient field current. A full-field test will indicate which component is faulty.

   b. To determine the alternator's ability to charge, the regulator must be bypassed so that the battery can send voltage directly to the alternator field circuit. This is what occurs during an alternator full-field test.

      (NOTE: Because the strength of the rotor's magnetic field is determined by battery potential, the battery should be at full charge when the alternator full-field test is performed.)

2. Equipment needed for the alternator full-field test

   a. Voltmeter

   b. Jumper lead (12 gauge)

      (NOTE: The automotive technician may encounter a variety of electrical connectors. It is, therefore, helpful to have several different jumper wires to ensure that a variety of jumper wire terminals are available.)

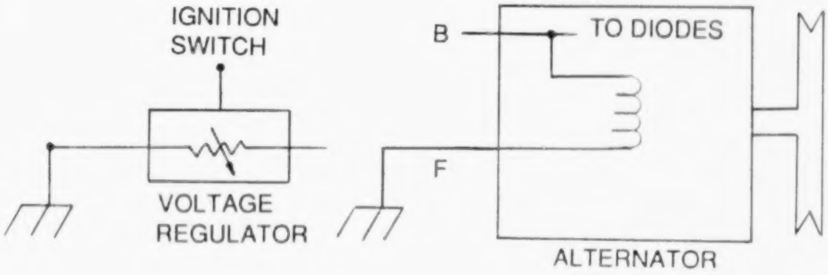
   c. 30-volt range voltmeter

   d. Small size allen wrench (for internal regulators in GM vehicles).

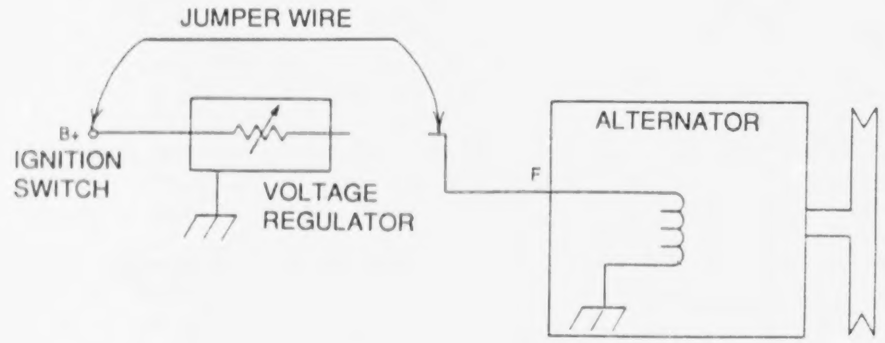
3. Special considerations when testing various alternator wiring arrangements

   a. When performing a full-field test on an alternator with an A-circuit wiring arrangement, make sure the field wire from the alternator is grounded while the engine is running.

      (NOTE: The manufacturer's wiring diagram will show what type of wiring arrangement the alternator uses.)



b. When performing a full-field test on an alternator with a B-circuit arrangement, the field wire must be supplied with battery positive (b+) voltage while the engine is running.



c. When performing a full-field test on an alternator with an isolated A or B circuit, supply B+ to one field lead while supplying a ground to the other. Keep the engine running at the specified RPM.

d. When performing a full-field test on an alternator with an isolated B circuit, supply B+ to one field lead, but make sure the grounding lead is already grounded externally to the alternator.

e. When performing a full-field test on an alternator with a computer-controlled isolated A or B circuit, be sure to follow the manufacturer's specific procedure for testing the fielding of the alternator. It is important to do so because a computer is controlling the field circuit. Usually the procedure will call for the technician to disconnect and ground the field control circuit to check its operation. Again, this should only be done in accordance with the manufacturer's procedure.

4. Procedure for alternator full-field test

   a. Connect voltmeter to battery, observe polarity, and note battery voltage.

   b. Determine the type of field circuit, and hook up the voltmeter leads appropriately.

      (NOTE: A VAT tester can also be used for this test.)

   c. Start engine and run it at the specified RPM.

   d. Complete the connections to full-field the alternator.

      (NOTE: Use the grounding tab on internally regulated alternators.)

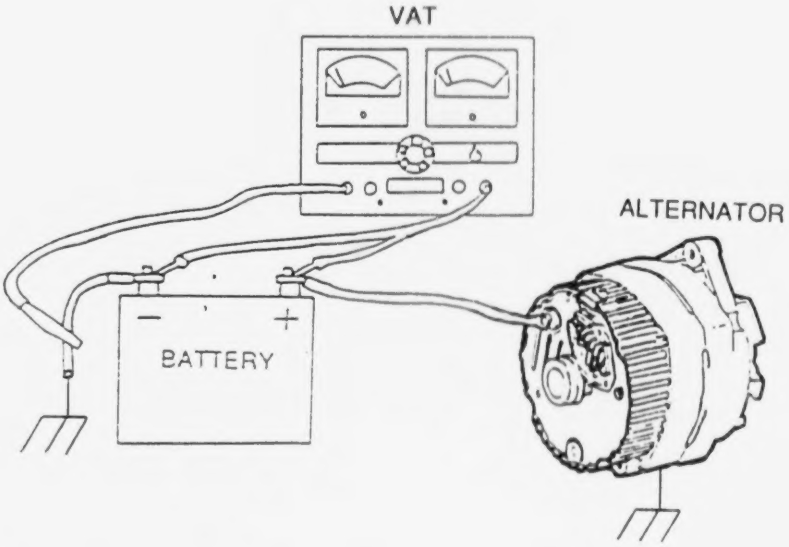
   e. Observe voltmeter reading. The reading should be within specification and at least one volt above static battery voltage observed in the above step.

f. If the voltage reading is correct, replace voltage regulator. If reading is below normal, rebuild or replace alternator.

D. Voltage regulator cutout test

1. The voltage regulator monitors battery potential in order to determine charging rate. To protect the battery, the voltage regulator maintains the charging rate at 13.5 - 14.8 volts. The voltage regulator cutout test reveals the regulator's ability to control the field circuit.

2. A voltmeter and carbon pile are needed for the voltage regulator cutout test. Both pieces of equipment are hooked in parallel to the battery.



3. Procedure for voltage regulator cutout test

   a. Start the engine and run it at an idle.

   b. Load the battery until it registers less than 10 volts.

   c. Turn off the load knob.

   d. Increase engine speed to appropriate test RPM.

   e. Observe voltmeter reading. The reading should rise steadily until reaching the specified level of regulator output and then fall off .2 to .5 volts. This indicates that the alternator has sufficiently recharged the battery and that the voltage regulator has adequately reduced the field current and charge rate.

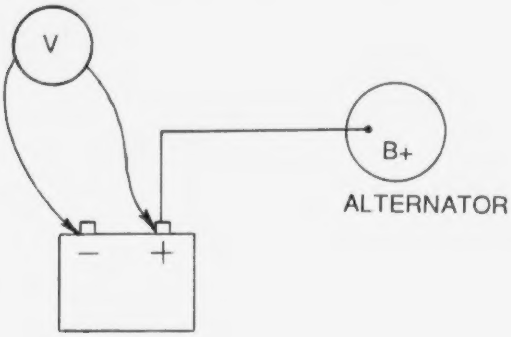
(NOTE: Before testing the voltage regulator cutout, test the battery load capacity and the alternator regulator output. The battery and charging circuit must be functioning properly if the voltage regulator cutout test is to be accurate.)

E. Complete circuit resistance test

1. A low-range voltmeter, a carbon pile, and an ammeter are needed for the insulated circuit test.

2. Procedure for complete circuit resistance test

   a. Connect voltmeter in parallel to the battery.



   b. Connect carbon pile to the circuit.

   c. Connect ammeter in series to the B+, or clamp the inductive pickup over either B+ or B-.

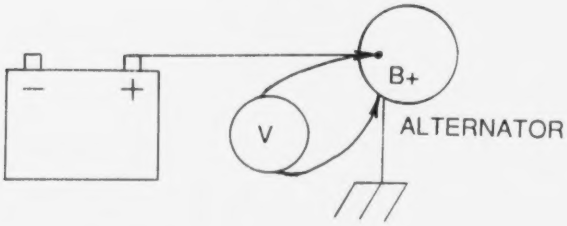
   (NOTE: A VAT may be substituted for an ammeter in this test.)

   d. Start engine and increase RPM to 2000.

   e. Rotate load-increase knob until the manufacturer's specified amperage is indicated on the ammeter.

   f. Observe and record voltmeter reading.

   g. Connect the voltmeter in parallel to the alternator (voltmeter positive to B+ alternator, voltmeter negative to a good alternator ground).



h. With the voltmeter connected in parallel to the alternator, repeat steps d, e, and f.

i. Record voltmeter reading and subtract it from the initial volt reading. The difference is the voltage drop across the complete circuit.

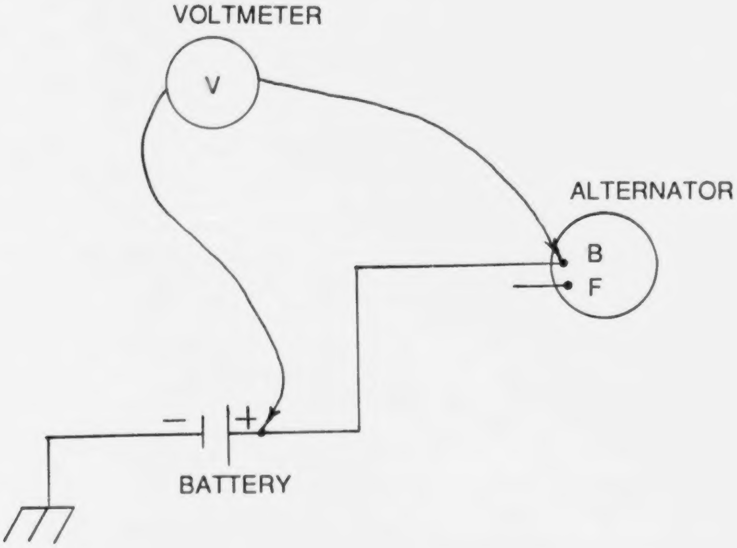
j. Compare the circuit voltage drop to the manufacturer's accepted maximum voltage drop, which is usually less than .9 volts.

F. Insulated circuit resistance test

1. The insulated circuit resistance test requires the same equipment as the complete circuit resistance test.

2. Procedure for the insulated circuit resistance test

   a. Connect voltmeter positive to B+ on the alternator and voltmeter negative to battery positive.



   b. Connect ammeter in series or with inductive pickup.

   c. Connect carbon pile in parallel with battery.

   d. Start the engine and increase RPM to 2000.

   e. Rotate lead knob until manufacturer's alternator output specification is indicated on the ammeter.

   f. Observe and record voltage reading.

   g. The voltmeter reading should be less than the manufacturer's specification, which is usually .5 volts.

G. Grounded circuit resistance test

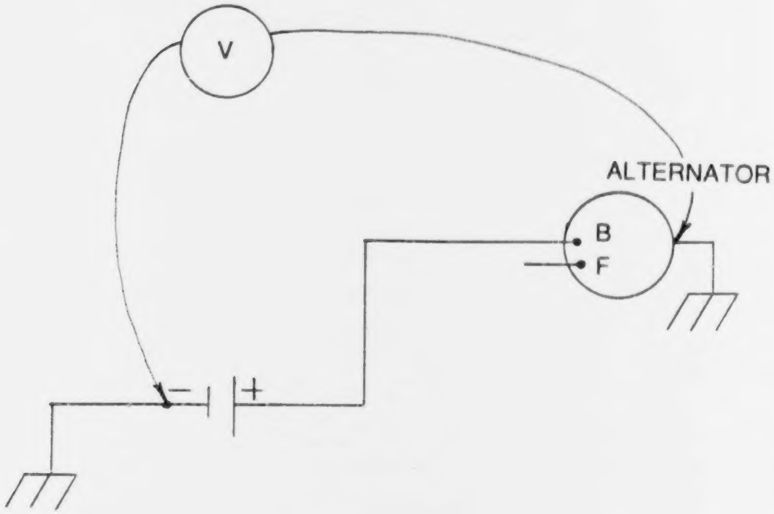
1. The grounded circuit resistance test requires the same equipment as the complete circuit resistance test.

2. Procedure for grounded circuit resistance test

   a. Connect voltmeter in parallel to the battery negative and the housing of the alternator.

   b. Connect ammeter either in series or with inductive pickup.

   c. Connect carbon pile in parallel to the battery.



   d. Start engine and increase RPM to 2000.

   e. Rotate load knob until the manufacturer's alternator output specification is indicated on the ammeter.

   f. Observe and record volt reading.

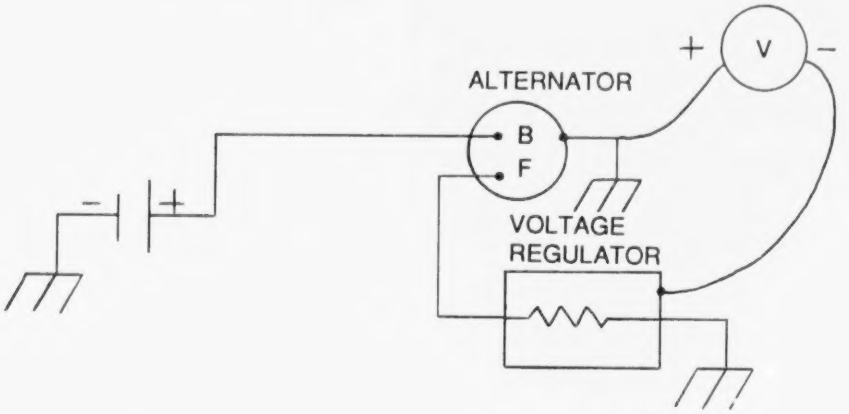
   g. The voltmeter reading should be less than the manufacturer's specification, which is usually .1 volt.

H. Voltage regulator ground circuit resistance test (for charging systems with external voltage regulators)

1. The voltage regulator ground circuit resistance test requires the same equipment as the complete circuit resistance test.

2. Procedure for regulator grounded circuit test

   a. Connect voltmeter in parallel to regulator ground and the housing of the alternator.



   b. Connect ammeter in series or with inductive pickup.

   c. Connect carbon pile in parallel to the battery.

   d. Start engine and run it at 2000 RPM.

   e. Rotate load knob until the ammeter reading reaches the manufacturer's specification.

   f. Observe and record volt reading.

   g. If reading is more than .1 volt, check for a poor connection between the regulator and ground or for a poor connection to the alternator if externally grounded.

I. Determining current requirements of a vehicle's charging system

1. If nonfactory electrical equipment has been added to a vehicle, its charging-system current capacity may have been exceeded. A shunt-type ammeter or inductive ammeter can be used to determine the current requirements of the system.

2. Procedure for determining charging system requirements.

   a. Connect ammeter in series or by an inductive pickup.

   b. Turn on all accessory equipment (including the ignition switch), but do not crank the engine.

   c. Record maximum ammeter reading. If the total current requirement is within 5 amps of the alternator, replace the alternator with a high-output alternator or reduce the number of electrical subsystems.

MODULE: ELECTRICAL SYSTEMS

PRELIMINARY TEST OF THE CHARGING SYSTEM

Equipment:

VAT
Service manual
Selected vehicle
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Conduct visual inspection of the charging system. Record observations. __ __ __ __

Battery	OK ____
Battery terminals	OK ____
Alternator drive belt condition	OK ____
Alternator drive belt tension	OK ____
Alternator wiring harness condition	OK ____
Alternator mounting	OK ____
Voltage regulator wiring harness	OK ____
Voltage regulator ground	OK ____

(NOTE: If any item above is not OK, make necessary repairs before proceeding with this job sheet.)

3. Perform battery state of charge test. For the proper procedure, refer to JS3-L2-UIV. According to this test the battery is: __ __ __ __

OK ___ NOT OK ___

(NOTE: If battery is NOT OK, recharge or replace it before continuing.)

4. Use an appropriate service manual to locate the manufacturer's rated output for the alternator. This information may also be stamped in the alternator housing . Record findings. __ __ __ __

Volts _____

Amps _____

RPM _____

Average of above evaluations* __ __ __ __

(*This average is a partial evaluation for Competency G1 and a final evaluation for Competency G4. Final evaluation for G1 will be made at the end of JS6-L1-UVIII.)

MODULE: ELECTRICAL SYSTEMS

ALTERNATOR OUTPUT TEST

Equipment:

VAT
Selected vehicle
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Put on safety glasses and wear while doing all procedures on this job sheet. ___ ___ ___ ___

   (NOTE: Item 2 below may be omitted if JS1-L1-UVIII has recently been completed. Check with the instructor.)

2. Complete preliminary test of the charging system. For the proper procedure, refer to JS1-L1-UVIII. Record observations. ___ ___ ___ ___

3. Following the procedure outlined below, perform alternator output test. ___ ___ ___ ___

   a. Connect the voltmeter and ammeter to the charging circuit (not always the large battery cables). Observe battery polarity. Try hooking inductive lead to output wire on back of alternator.

   b. Start the engine and run at idle.

   c. Turn off all unneeded loads.

   d. Record the output volts and amps.

      Volts ____
      Amps ____

   e. Bring the engine up to manufacturer's specifications and record the volts.

      Volts ____

   f. With engine at specified RPM, turn the load knob until highest amps are achieved, but do not let the voltage drop below 12 volts.

(NOTE: Voltage output should be 12.5 to 14 volts. Amp output should not be within 8 amps of the manufacturer's rating.)

g. Turn load knob to off and record reading obtained in step f.

Volts ___ Amps ___

According to this test the alternator output is:

OK ___ NOT OK ___

h. If alternator output is NOT OK, recommend steps that can be taken to correct the situation.

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency G1. Final evaluation for G1 will be made at the end of JS6-L1-UVIII.)

MODULE: ELECTRICAL SYSTEMS

ALTERNATOR FULL-FIELD TEST

Equipment:

Voltmeter
Jumper wire
Small screwdriver or allen wrench
VAT (optional)
Selected vehicle
GM internal regulator
Safety glasses

Procedure: Evaluation 3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

   (NOTE: The alternator full-field test can be performed with a VAT. The manufacturers of the VAT will usually provide the appropriate procedure.)

2. Using a service manual, determine the type of field circuit used in the alternator to be serviced. Also determine the correct charging system voltage. Record findings. ___ ___ ___ ___

   Specification

   Alternator

   Voltage regulator setting (volts)

   Type A circuit
   Type B circuit

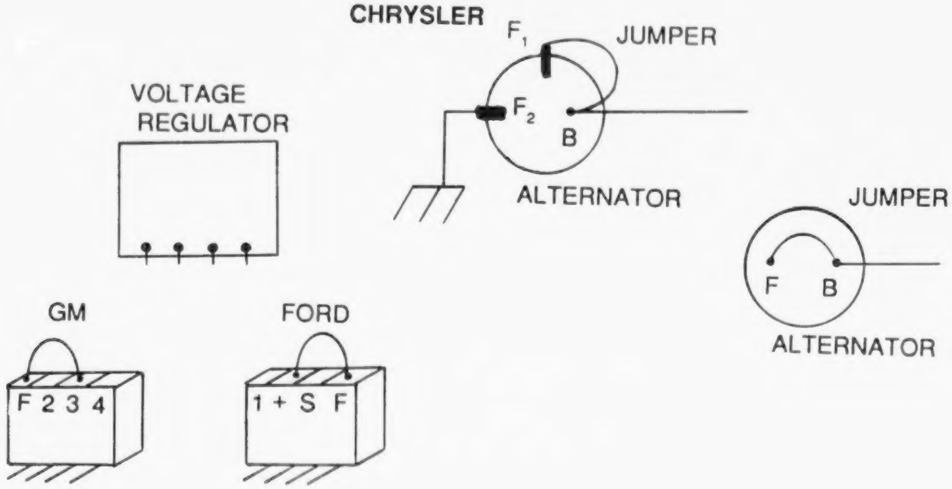
   Charging system output (amps)
   RPM at which test should be performed

3. Using the procedure outlined below, perform alternator full-field test. ___ ___ ___ ___

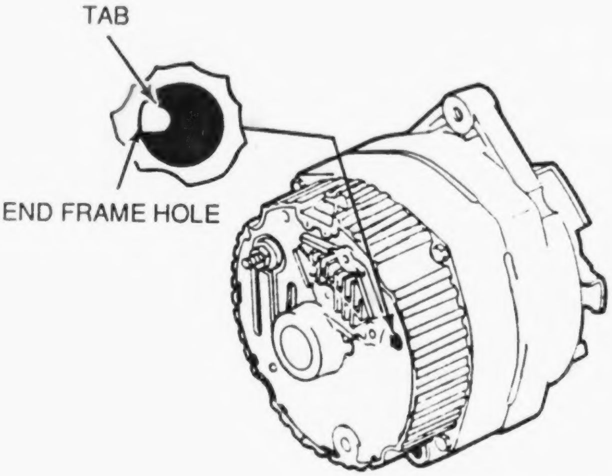
   a. Connect voltmeter to battery, observe polarity and note battery voltage.

b. Determine the best location for jumping the field circuit (external regulator). Use the drawing below to help complete the following test.

(NOTE: The full-field test can be performed at either the regulator or alternator.)

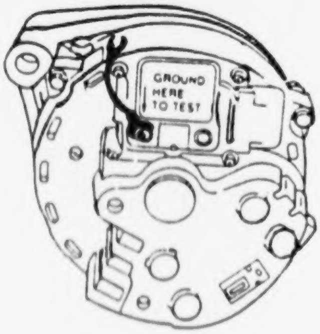

CHRYSLER
F_1
JUMPER
VOLTAGE REGULATOR
F_2
B
ALTERNATOR
JUMPER
F
B
ALTERNATOR
GM
F 2 3 4
FORD
1 + S F

(NOTE: When performing this test on a GM vehicle, insert a screwdriver or small "L-shaped" wire into a test hole on the back of the alternator. The tool should be pushed in only far enough to touch the tap. Pushing the tool too far may damage the alternator.)


TAB
END FRAME HOLE

Courtesy of General Motors Corporation

(NOTE: When performing this test on a Ford vehicle, insert a jumper wire between the voltage regulator test terminal [on the back of the alternator] and a good ground.)



c. Jump the field circuit.

(NOTE: It may be necessary to remove the wiring harness from the voltage regulator in order to jump the field circuit.)

d. Start the engine and run at specified RPM.

e. Complete the field connection so that the system is bypassing the voltage regulator.

(CAUTION: Do not allow the voltage to exceed 16.5 volts.)

f. Record voltmeter reading.

g. According to this test, the charging system is:

OK ___ Not OK ___

h. If not OK, recommend steps that can be taken to correct the problem.

Average of above evaluations* ____

(*This average is a partial evaluation for Competency G1. Final evaluation for G1 will be made at the end of JS6-L1-UVIII.)

MODULE: ELECTRICAL SYSTEMS

VOLTAGE REGULATOR CUTOUT TEST

Equipment:

Voltmeter
Carbon pile
VAT (optional)
Serviceable vehicle
Safety glasses

Procedure:	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2. Determine the correct charging system voltage and desired test RPM.	__ __ __ __
Voltage regulator setting ________	
Desired test RPM ________	
3. Using the procedure outlined below, perform voltage regulator cutout test.	__ __ __ __

a. Connect voltmeter to the battery. Be sure to observe polarity.*

b. Connect carbon pile to the battery.*

(*VAT may be substituted here.)

c. Start the engine and run at idle.

d. Load the battery until the battery voltage reads below 10 volts.

e. Turn off load control knob.

f. Increase engine speed to desired test RPM.

g. Observe voltmeter (voltmeter should rise to upper limit of voltage regulator setting and fall off .2 to .5 volts).

h. According to this test, the charging system is:

OK ___ NOT OK ___

i. If the charging system is NOT OK, recommend steps to correct the situation.

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency G1. Final evaluation for G1 will be made at the end of JS6-L1-UVIII.)

MODULE: ELECTRICAL SYSTEMS

CHARGING CIRCUIT RESISTANCE TEST

Equipment:

Voltmeter
Carbon pile
VAT (optional)
Serviceable vehicle
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Following the procedure outlined below, perform a charging circuit resistance test. __ __ __ __

    a. Connect voltmeter in parallel to battery and record reading.

    b. Connect carbon pile to the circuit.

    c. Connect ammeter to the circuit.

    d. Run engine at 2000 RPM.

    e. Increase the load until the charging system reaches manufacturer's specified output.

    f. Observe and record voltmeter reading.

       Volts ____

    g. Connect voltmeter in parallel to the alternator.

    h. Repeat steps d and e and record voltmeter reading.

       Volts ____

    i. Subtract the reading for step f from the reading for step h. Record the complete circuit voltage drop.

       Voltage drop ____

    j. According to this test, the voltage drop for the complete circuit is:

       within specifications __

       not within specifications __

k. If not within specifications, recommend steps that can be taken to correct the problem.

3. Using the procedure outlined below, perform an insulated circuit resistance test. — — — —

   a. Connect the voltmeter positive to the B + on the back of the alternator, and the voltmeter negative to the battery positive terminal.

   b. Connect ammeter in series or with inductive pickup.

   c. Connect carbon pile in parallel with battery.

   d. Start the engine and increase RPM to 2000.

   e. Rotate load knob until manufacturer's alternator output specification is indicated on ammeter.

   f. Record positive circuit voltage drop.

      Voltage drop _____

   g. Indicate below whether or not the insulated circuit voltage drop is within specifications. If not within specifications, recommend steps to correct the situation.

      Within specifications _______

      Not within specifications ______

4. Using the procedure outlined below, perform a ground circuit resistance test. — — — —

   a. Connect the voltmeter positive to the battery negative terminal and the voltmeter negative to any good ground on the back of the alternator.

   b. Connect ammeter in series or with inductive pickup.

   c. Connect carbon pile in parallel with battery.

d. Start the engine and increase RPM to 2000.

e. Rotate load knob until manufacturer's alternator output specification is indicated on ammeter.

f. Record ground circuit voltage drop.

Voltage drop ____

g. Indicate below whether or not the insulated circuit voltage drop is within specifications. If not within specifications, recommend steps to correct the problem.

Within specifications ______

Not within specifications ______

5. Using the procedure outlined below, perform a voltage regulator ground circuit resistance test. (This procedure is for charging systems with external voltage regulators.) __ __ __ __

a. Connect the voltmeter positive to any good ground on the back of the alternator and the voltmeter negative to any good ground on the regulator case.

b. Connect ammeter in series or with inductive pickup.

c. Connect carbon pile in parallel with battery.

d. Start the engine and increase RPM to 2000.

e. Rotate load knob until manufacturer's alternator output specification is indicated on ammeter.

f. Record voltage regulator ground circuit voltage drop.

Voltage drop ____

g. Indicate below whether or not the insulated circuit voltage drop is within specifications. If not within specifications, recommend steps to correct the problem.

Within specifications ______

Not within specifications ______

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency G1. Final evaluation for G1 will be made at the end of JS6-L1-UVIII.)

MODULE: ELECTRICAL SYSTEMS

DETERMINING CHARGING SYSTEM REQUIREMENTS

Equipment:

Ammeter
VAT (optional)
Serviceable vehicle
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

   (NOTE: Item 2 below may be omitted if JS2-L1-UVIII has recently been completed. Check with the instructor.)

2. Determine the maximum output of the alternator on the vehicle to be serviced. Record observations. For the proper procedure, refer to JS2-L1-UVIII. ___ ___ ___ ___

   Alternator output ________

3. Using the procedure outlined below, determine current demand for the vehicle to be serviced. ___ ___ ___ ___

   a. Connect ammeter to circuit.

   b. Turn on all accessories and load devices.

   c. Record maximum ammeter reading.

   d. According to this test, the charging system is

      OK ___

      NOT OK ___

e. If the charging system is not OK, recommend steps that can be taken to correct the problem.

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency G1. Final evaluation for G1 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

Using the spaces provided below, determine the student's final evaluation for Competency G1 by averaging the final evaluation of JS1-L1-UVIII through JS6-L1-UVIII.

	Evaluation			
	3	2	1	N
JS1-L1-UVIII	—	—	—	—
JS2-L1-UVIII	—	—	—	—
JS3-L1-UVIII	—	—	—	—
JS4-L1-UVIII	—	—	—	—
JS5-L1-UVIII	—	—	—	—
JS6-L1-UVIII	—	—	—	—
Final evaluation for Competency G1	—	—	—	—

MODULE: ELECTRICAL SYSTEMS

UNIT VIII: CHARGING SYSTEM DIAGNOSIS AND REPAIR

UNIT VIII TEST

SECTION A. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 1. In an "A" circuit alternator, the field circuit is grounded in the voltage regulator.

____ 2. In a "B" circuit alternator, the field circuit is grounded to the battery casing.

____ 3. A belt tension gauge measures in pounds of tension.

____ 4. Full fielding is the process of supplying minimum current flow through the field circuit in order to measure minimum alternator output.

____ 5. An insulated circuit resistance test measures resistance in the insulated portion of the charging circuit.

____ 6. The isolated "A" or "B" circuit can ground the field circuit in either the alternator or the regulator.

____ 7. The regulator bypass is a means by which the field- control portion of the voltage regulator can be bypassed so that the field can receive maximum alternator output.

____ 8. The serpentine belt is actually two interwoven belts.

____ 9. The shunt ammeter uses several external shunt bars to measure current flow.

____ 10. The V-belt performs some minor charging system functions; its primary purpose, however, is to drive the power steering pump.

____ 11. Some vehicles provide an adjusting or tensioning screw to adjust V-belt tension.

____ 12. The multirib belt is essentially a group of miniature V-belts bonded together to form a single flat belt.

____ 13. The serpentine belt requires very low tension for maximum efficiency.

____ 14. The serpentine belt may use an idler pulley, which also serves as a tensioner.

____ 15. Some vehicles provide a slotted hole for V-belt adjustment.

SECTION B. Read each of the below statements made by technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.

____ 16. Technician I says that a V-belt should be replaced if it is oil-soaked.

Technician II says that adding tension to a V-belt will prevent its inside face from bottoming in the pulley.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 17. Technician I says that the alternator's voltage regulator determines a battery's state of charge by measuring battery voltage (potential difference).

Technician II says that the test procedure for measuring maximum regulated output of the alternator must be based upon battery voltage.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 18. Technician I says that, during an alternator output test, a carbon pile should be used to increase battery voltage.

Technician II says that, during an alternator output test, the voltage regulator senses any increase in battery voltage and responds by increasing the field current in the alternator.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 19. Technician I says that, when performing an alternator output test, an inductive or shunt ammeter with a 50 to 75-amp range is needed.

Technician II says that, when performing an alternator output test with a shunt-type ammeter, a heavy-duty switch will be needed to open the battery circuit so that the ammeter can be placed in series.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 20. Technician I says that a tachometer can be used to establish engine RPM during the alternator output test.

Technician II says that it is necessary to establish precise engine RPM during the alternator output test.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 21. Technician I says that, before performing an alternator output test, the drive belt should be checked for wear and looseness.

Technician II says that, before performing an alternator output test, the drive belt should always be replaced with one that is known to be in excellent condition.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 22. Technician I says that, if an alternator output test determines that alternator output is below specification, an alternator full-field test should be performed.

Technician II says that, if an alternator output test determines that alternator output is above specification, the alternator must be replaced.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 23. Technician I says that failure of the alternator and regulator assembly to produce sufficient current may be due to the alternator's inability to charge.

Technician II says that failure of the alternator and regulator assembly to produce sufficient current may be due to the voltage regulator's failure to supply sufficient field current.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 24. Technician I says that bypassing the regulator and supplying between 3 or 4 volts directly to the alternator will determine the alternator's ability to charge.

Technician II says that the alternator's ability to charge can best be tested by monitoring battery voltage while the starter is cranking.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 25. Technician I says that, during a full-field test of an A-circuit alternator, the alternator's field wire should be grounded while the engine is running at the specified RPM.

Technician II says that, during a full-field test of a B-circuit alternator, the field wire must be supplied with battery positive voltage while the engine is running at the specified RPM.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 26. Technician I says to follow the manufacturer's procedures when performing a full-field test on an alternator with a computer-controlled isolated A or B circuit.

Technician II says that, during a full-field test of an alternator with a computer-controlled isolated circuit, the field control circuit should usually remain connected.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 27. Technician I says that the voltage regulator uses engine RPM to determine charge rate.

Technician II says that, in order to prevent the battery from becoming overcharged, the voltage regulator controls the charging rate at 13.5 to 14.8.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 28. Technician I says that a voltage regulator cutout test will reveal the regulator's ability to control the field circuit.

Technician II says that a voltage regulator cutout test reveals the regulator's ability to control the amount of battery voltage used by the starter motor.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 29. Technician I says that, before a voltage regulator cutout test is performed, the starting system must be checked for shorts and grounds.

Technician II says that, in order for the voltage regulator cutout test to be accurate, both the battery and charging circuit should be tested to ensure that they are functioning properly.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 30. Technician I says that, if nonfactory electrical subsystems have been added to the vehicle, charging system requirements may have been exceeded.

Technician II says that, as long as the charging circuit requirement test is within 5 amps of the alternator (output), more electrical subsystems can be added to the vehicle.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of _____ on the Unit VIII Test in order to receive an evaluation for Competencies G1 and G4.)

ANSWERS TO UNIT VIII TEST

1. t
2. f
3. t
4. f
5. t
6. f
7. t
8. f
9. f
10. f
11. t
12. t
13. f
14. t
15. t
16. a
17. c
18. d
19. b
20. a
21. a
22. a
23. c
24. d
25. c
26. c
27. b
28. a
29. b
30. a

MODULE: ELECTRICAL SYSTEMS

UNIT IX: INSPECTING, REPAIRING, AND REPLACING CHARGING SYSTEM COMPONENTS

UNIT OBJECTIVE

After completing this unit, the student should be able to inspect, repair, and replace charging system components. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1. I. Identify various charging system components (Competencies G2-G3, Unit IX Test).

II. Identify the procedures for removing and installing charging system components (Competencies G2-G4, Unit IX Test).

III. Identify the procedures for testing, inspecting, and repairing an alternator (Competencies G2-G3, Unit IX Test).

IV. Demonstrate the ability to:

  a. Remove and reinstall an alternator (Competency G2, JS1-L1-UIX).

  b. Service an alternator (Competency G3, JS2-L1-UIX).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks F035-F043.

MODULE: ELECTRICAL SYSTEMS

UNIT IX: INSPECTING, REPAIRING, AND REPLACING CHARGING SYSTEM COMPONENTS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: INSPECTING, REPAIRING, AND REPLACING CHARGING SYSTEM COMPONENTS

    a. Information outline

    b. Assignment sheets

      AS1-L1-UIX: Procedure for Removal and Reinstallation of the Alternator
      AS2-L1-UIX: Procedure for Alternator Service

    c. Job sheets

      JS1-L1-UIX: Removing and Reinstalling an Alternator
      JS2-L1-UIX: Servicing an Alternator

E. Unit test

F. Answers to unit test

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Chrysler Motors. 1988 Service Manual: Electrical, Fuel, and Emission Systems: Front Wheel Drive Car.

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NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Students should perform AS1-L1-UIX in conjunction with JS1-L1-UIX and AS2-L1-UIX in conjunction with JS2-L1-UIX.

MODULE: ELECTRICAL SYSTEMS

UNIT IX: INSPECTING, REPAIRING, AND REPLACING CHARGING SYSTEM COMPONENTS

LESSON 1: INSPECTING, REPAIRING, AND REPLACING CHARGING SYSTEM COMPONENTS

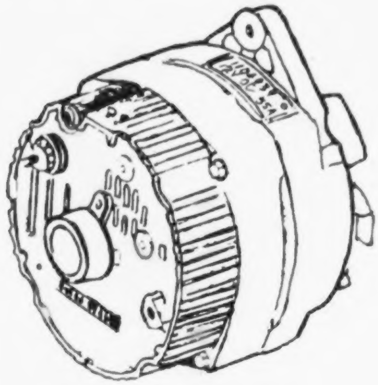
I. Identifying charging system components

   A. The various types of alternators

      1. Alternators may use either an external or an internal regulator. Most later-model vehicles use alternators with internal regulators. An internally regulated alternator accomplishes field control in much the same way as an externally regulated alternator. Field-control activity, however, occurs inside an internally regulated alternator through the use of electronic circuitry.

      2. Alternators have various charging rates. The technician must know the charging rate of the alternator that he or she is servicing.

         a. A model number indicating an alternator's charging rate is sometimes stamped on the housing (for example, the number 55A would usually indicate a 55 amp alternator). It may be necessary to cross reference the model number to a service manual.



         b. Sometimes a metal tag denoting the alternator's charging rate is attached to a housing screw. The tag may have to be cross referenced to a service manual.

         c. Sometimes manufacturers will put a colored dot on an alternator to indicate its charging rate. The dot is usually found on the alternator's housing. Matching the color of the dot to the manufacturer's specifications table will indicate the alternator's expected charging rate.

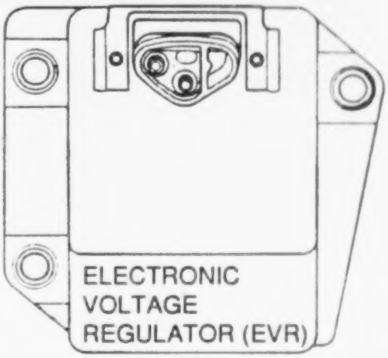
4. If a vehicle's electrical load has been increased since its manufacture, a higher output alternator may be required.

B. The various types of voltage regulators

1. The external voltage regulator

a. Some external voltage regulators use magnetic coils to control charging rate. The regulator turns off the field circuit when the engine is not running.

b. Other external voltage regulators use electronic circuitry to control the field circuit. These voltage regulators are referred to as electronic or solid state voltage regulators.

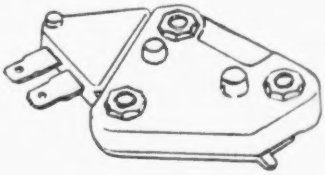


Courtesy of Chrysler Motors

2. The internal voltage regulator

a. The internal voltage regulator uses electronic circuitry to control the field.

b. The internal voltage regulator is located either on or inside the alternator housing.



C. Some manufacturers use a computer-controlled relay to engage or disengage the field regulator circuit.

D. The charge indicator

1. All vehicles have some type of charge indicator, which tells the driver if the alternator is able to recharge the battery and supply current to the vehicle's electrical system while the engine is running.

2. Vehicles can use any or all of the following types of charge indicators listed below.

a. An indicator light

b. An ammeter

c. A voltmeter

II. Removing and installing charging system components

A. Procedure for removing an alternator

1. Remove battery ground cable.

2. Remove wire leads from alternator.

(**CAUTION:** Do not remove the alternator's battery lead unless the ground cable has been removed from the battery.)

3. Remove the alternator belt-adjusting bolt and loosen the other alternator mounting bolts.

4. Move the alternator toward the engine.

5. Remove the alternator belt from the alternator pulley.

6. Remove the bolts holding the alternator to the engine mounting bracket.

7. Lift the alternator out of the bracket.

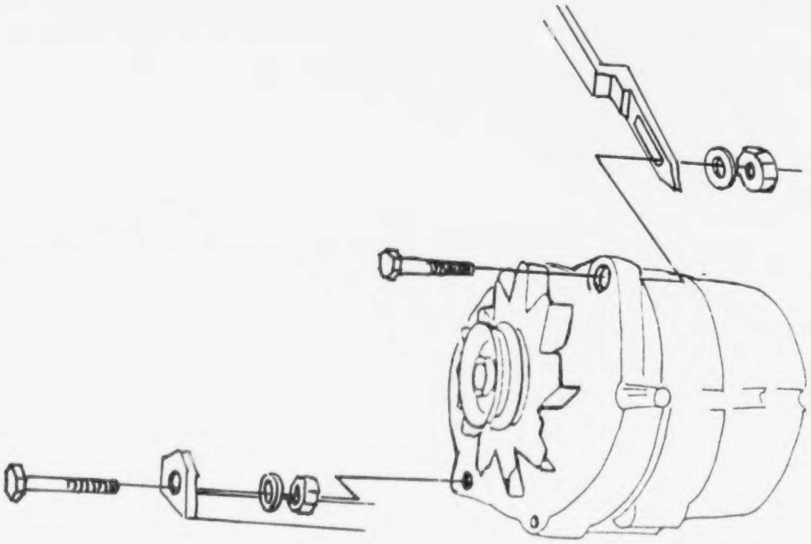
8. Service alternator as required.

B. Procedure for replacing an alternator

1. Position the alternator in the engine mounting bracket.

2. Replace alternator retaining bolts.

3. Position alternator belt on pulley. Move alternator away from the engine to tighten belt.



4. Pry the alternator away from the engine to adjust alternator belt tension.

   (NOTE: Adjusting the alternator belt improperly can cause serious damage. Refer to the manufacturer's recommendations for tightening procedures.)

5. Install the alternator adjusting bolt.

6. Check alternator belt tension with a belt tension gauge. Adjust tension to manufacturer's specifications.

7. Attach alternator wire leads and tighten them securely.

8. Install battery ground cable.

   (**CAUTION:** Never attempt to polarize an alternator.)

C. Special considerations when removing or replacing an external regulator.

1. Some regulators use an insulated mount.

   (NOTE: When installing a regulator, exercise care in replacing insulated washers.)

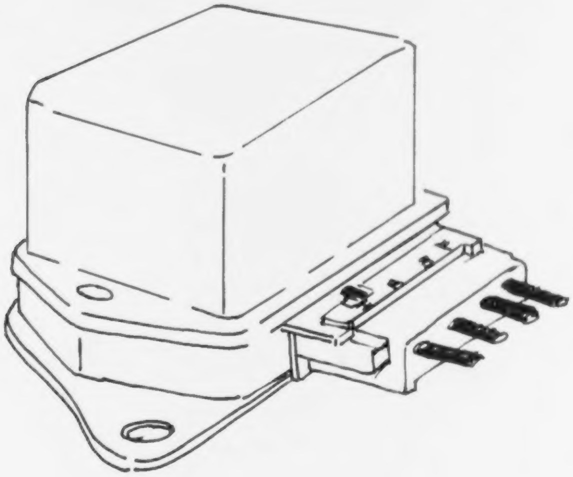
2. Most alternators and regulators are grounded by the vehicle chassis.

   (NOTE: When replacing the regulator, care must be taken to ensure that the mounting screws provide a good ground.)

3. Terminal ends

   a. Plastic locking tabs provide regulators a fail-proof connection.

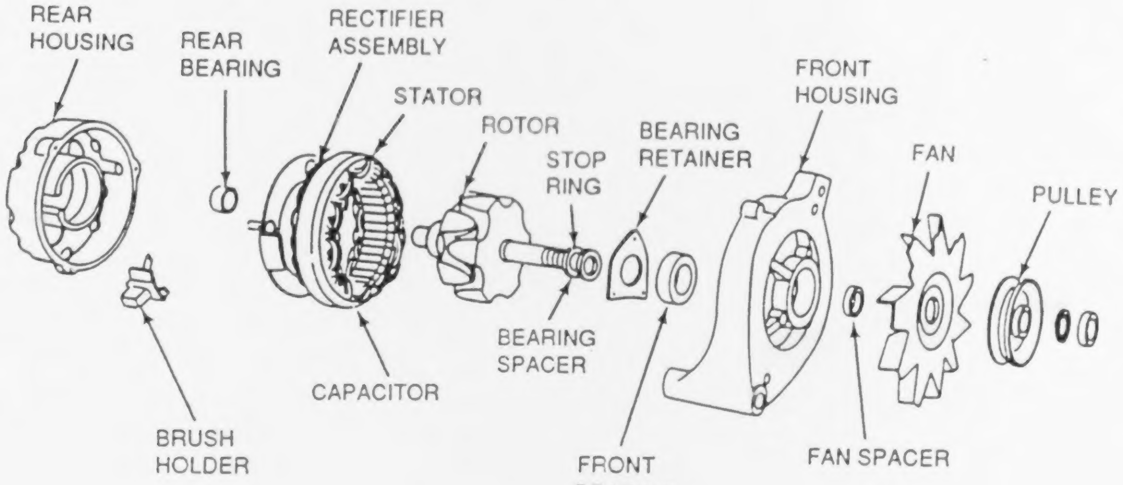
   b. Terminal ends should be free of dirt and corrosion. Special terminal cleaning brushes can be used to scour terminal connections. Some manufacturers apply waterproofing grease inside the connector.



III. Testing, inspecting, and repairing the alternator

A. Procedure for disassembling the alternator

1. Remove the through bolts and separate the stator and rectifier-end frame from the drive-end frame.


REAR HOUSING
REAR BEARING
RECTIFIER ASSEMBLY
STATOR
ROTOR
STOP RING
BEARING RETAINER
FRONT HOUSING
FAN
PULLEY
BEARING SPACER
CAPACITOR
BRUSH HOLDER
FRONT BEARING
FAN SPACER

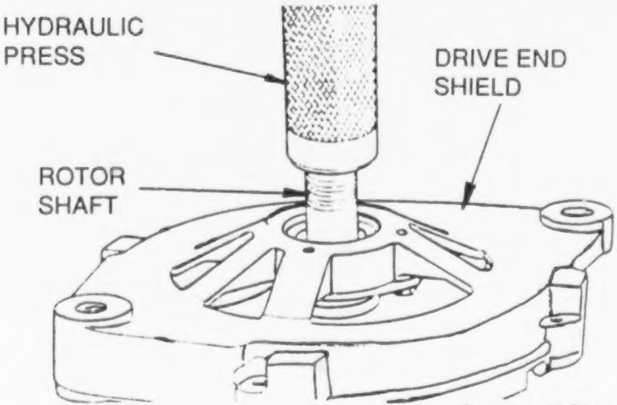
2. Remove stator lead, rectifier, and capacitor and separate rectifier and insulator from alternator.

3. Separate stator from the rectifier-end frame.

4. Remove brush holder and rectifier from rectifier-end frame.

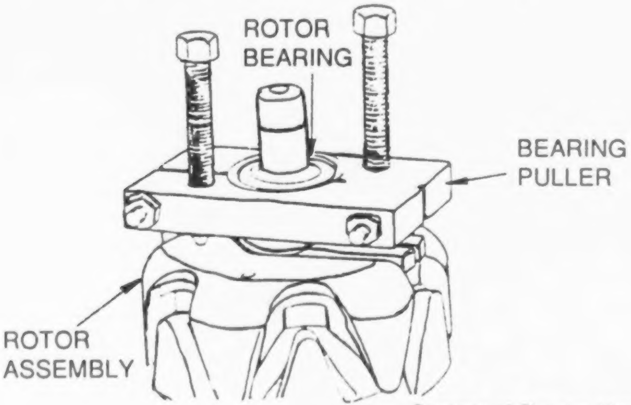
5. Remove drive pulley nut and washer; then, remove pulley and fan from rotor.

6. Press the rotor shaft from the drive-end shield. If the bearing is defective, the drive-end shield assembly must be replaced.



Courtesy of Chrysler Motors

7. Using a bearing puller, remove the rectifier-end bearing.



Courtesy of Chrysler Motors

(NOTE: To install the rectifier-end bearing, position the rotor assembly in a holding fixture and use a driver to force the bearing onto the shaft.)

(NOTE: To reassemble an alternator, reverse the above procedure.)

B. Make sure that the brushes move in smoothly and return all the way to the stops when released. If the brushes do not move properly, replace the brush holder assembly.

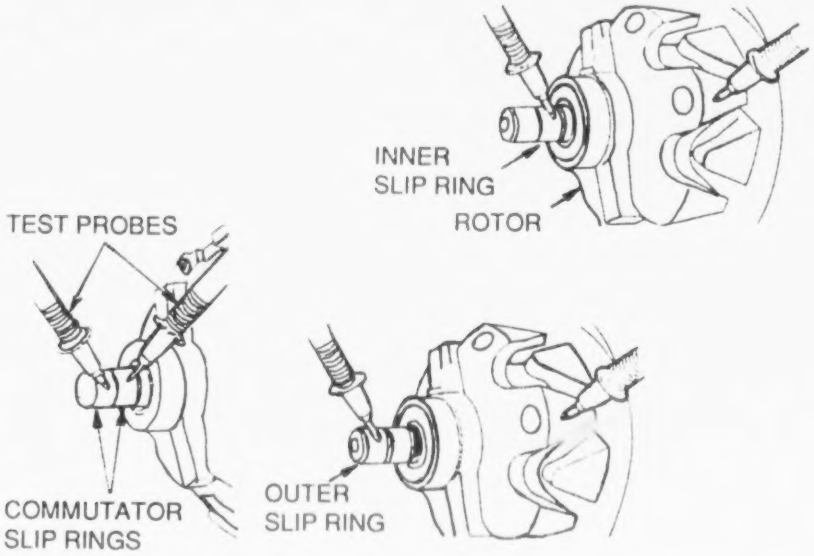
C. Procedure for rotor test

1. Inspect the field slip rings for excessive wear or roughness. Minor damage can be dressed out with a fine emery cloth. If the slip rings are damaged badly enough, the rotor must be replaced.

2. Using an ohmmeter, test for continuity from one slip ring to the other. The circuit should be closed.

3. Using an ohmmeter, test for continuity from both of the field coil slip rings to the rotor shaft or core. The circuit should test open.

4. If failure is detected, replace the rotor.



Courtesy of Chrysler Motors

D. Procedure for testing the stator

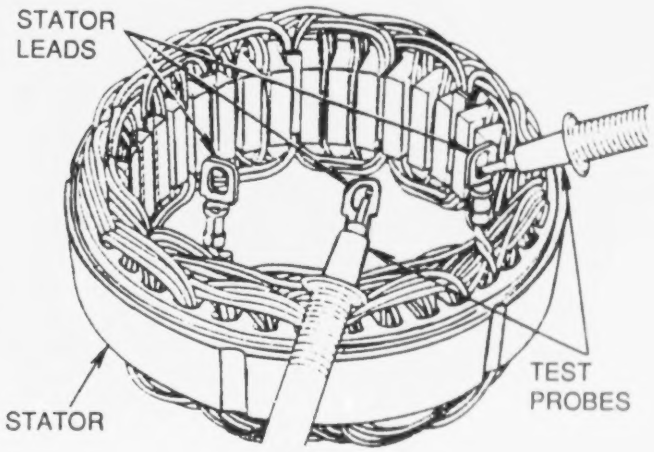
1. Inspect the stator for signs of damage (weak or broken leads, distorted frame, or burned windings).

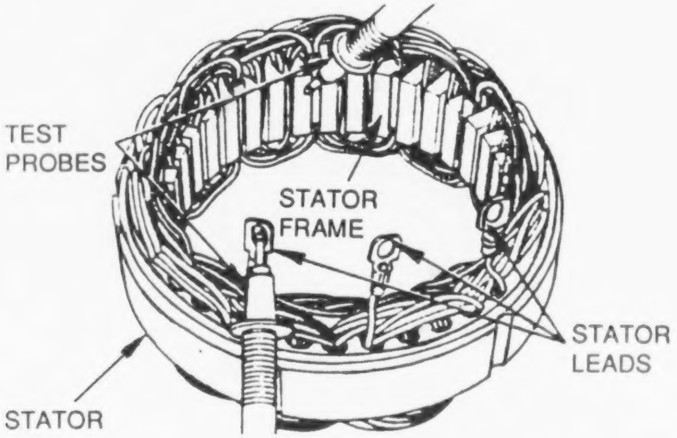
2. Using a scraper, clean a small area of the stator frame to ensure a good electrical contact.

3. Using an ohmmeter, test for continuity from the stator leads to the frame. The circuit should test open.

4. Test continuity from one stator lead to the other leads. The circuit should be closed.

5. If failure is detected, replace the stator.


STATOR LEADS
TEST PROBES
STATOR


TEST PROBES
STATOR FRAME
STATOR LEADS
STATOR

Courtesy of Chrysler Motors

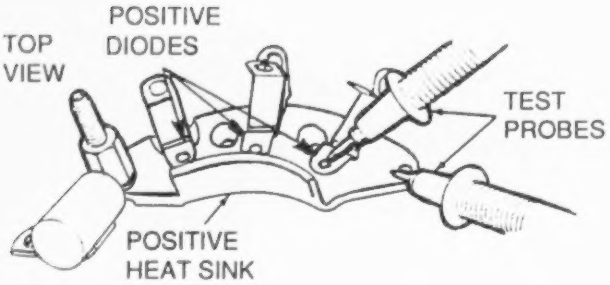
E. Procedure for testing the rectifier

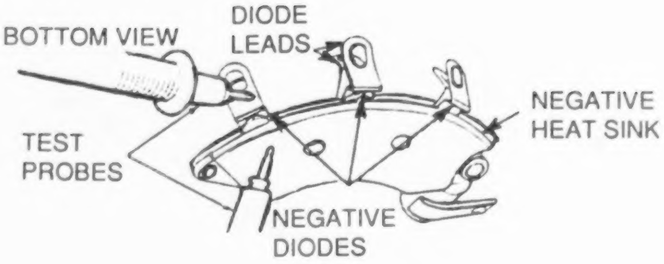
1. Separate the positive diode leads from the negative diode leads.

2. Using an ohmmeter, test for continuity from each of the positive diode leads to the positive heat sink; then reverse the test probes and repeat the test. The result should show continuity in one direction only.

3. Using the ohmmeter, test for continuity from each of the negative diode leads to the negative heat sink. Then, reverse the test probes and repeat the test. The result should show continuity in one direction only.

4. If failure is detected in the above tests, replace rectifier assembly.


TOP VIEW
POSITIVE DIODES
TEST PROBES
POSITIVE HEAT SINK


BOTTOM VIEW
DIODE LEADS
NEGATIVE HEAT SINK
TEST PROBES
NEGATIVE DIODES

Courtesy of Chrysler Motors

MODULE: ELECTRICAL SYSTEMS

PROCEDURE FOR REMOVAL AND REINSTALLATION OF THE ALTERNATOR

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing the alternator from the vehicle to be serviced.
3. Record the maximum alternator (rotor) shaft end play.
4. Record the proper drive belt tension for the alternator.
5. Explain how to check alternator drive belt tension.
6. List the procedures for reinstalling the alternator. Include the torque specifications for the mounting bolts.

MODULE: ELECTRICAL SYSTEMS

PROCEDURE FOR ALTERNATOR SERVICE

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Develop a written procedure for disassembling the alternator to be serviced. List any special tools that may be required.

2. Develop a written procedure for testing the components in the alternator to be serviced. Use the chart below as a guide.

   Test rectifier assembly:

   Positive diodes
   Negative diodes

   Test diode trio (Delco-Remy alternators)

   Test rotor assembly:

   Ground test
   Continuity test

   Test stator:

   Ground test
   Continuity test

   Test capacitor:

   Short circuited
   Capacity

   Check bearings:

   Drive-end bearings
   Rectifier-end bearings

3. Develop a written procedure for reassembling the alternator to be serviced. List any special tools required and all applicable torque specifications.

JS1-L1-UIX

MODULE: ELECTRICAL SYSTEMS

REMOVING AND REINSTALLING AN ALTERNATOR

Equipment:

Hand tools
Torque wrench
Belt-tension gauge
Serviceable vehicle
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Complete AS1-L1-UIX. ___ ___ ___ ___

3. Following the procedure outlined below, remove the alternator. ___ ___ ___ ___

    a. Remove the negative battery cable.

    b. Using the procedure developed in AS1-L1-UIX, remove the alternator.

    c. Check the alternator bearings. Record observations.

    (HINT: To check alternator bearings, spin the rotor and listen for excessive noise. Try to move the rotor shaft either in or out, or up or down to detect excessive free play.)

4. If an alternator test stand is available, bench test the alternator. Consider the items listed below. ___ ___ ___ ___

    a. Use the procedure supplied by the manufacturer of the alternator test stand to complete the test. Record observations.

    Alternator output:

    Volts ___

    Amps ___

b. According to the bench test, the alternator is:

OK ___ NOT OK ___

If NOT OK, recommend steps to correct the problem.

5. Using information from either a service manual or Unit VII of this module, determine the condition of the alternator drive belt. _ _ _ _

a. The alternator drive belt is:

OK ___ Fair ___

Poor ___ Bad ___

b. Justify the belt rating.

Average of above evaluations* _ _ _ _

(*This average is a final evaluation for Competency G2.)

JS2-L1-UIX

MODULE: ELECTRICAL SYSTEMS

SERVICING AN ALTERNATOR

Equipment:

Hand tools
Ohmmeter
Diode tester (optional)
Electric motor cleaner
Pulley puller
Driver or press for replacing bearings
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Complete AS2-L1-UIX __ __ __ __

3. If necessary, remove the alternator from the vehicle. For the proper procedure, refer to JS1-L1-UIX. __ __ __ __

4. Clean and disassemble the alternator. Follow the procedure outlined below. __ __ __ __

    a. Clean the outside of the alternator case with electric motor cleaner.

    b. Using the procedure developed in AS2-L1-UIX, disassemble the alternator.

    c. If needed, clean the components inside the alternator with electric motor cleaner. Wipe or blow dry.

5. Test and replace alternator components. __ __ __ __

    a. Using the procedure developed in AS2-L1-UIX, test the alternator's components. Use the following chart to record the condition of each component tested.

Test rectifier assembly:

Diode tester and instruction in crib:

Positive diodes		Negative diodes	
Bad __	OK __	Bad __	OK __
Bad __	OK __	Bad __	OK __
Bad __	OK __	Bad __	OK __

Test diode trio (Delco Remy Alternators):

Bad __ OK __

Test rotor assembly:

Ground test: Bad __ OK __

Continuity test: Bad __ OK __

Test stator:

Ground test: Bad __ OK __

Continuity test: Bad __ OK __

Test capacitor:

Short Circuited Bad __ OK __

Check bearings:

Drive-end bearings: Bad __ OK __

Rectifier-end bearings: Bad __ OK __

Brush condition: Bad __ OK __

b. Replace any alternator components that are found to be defective.

c. Using a small piece of fine grit abrasive cloth, polish the slip ring surface.

6. Following the procedure outlined below, reassemble the alternator. — — — —

a. Lubricate the rectifier-end bearing with a small quantity of light grease.

b. Following the procedure developed in AS2-L1-UIX, reassemble the alternator.

7. If an alternator test stand is available, bench test the alternator. Consider the items listed below. __ __ __ __

a. Use the procedures that the manufacturer supplied with the alternator test stand to complete the test. Record observations.

Output:

Volts ___

Amps ___

(NOTE: Alternator current output should be within 5 amps of the manufacturer's specification. Alternator voltage output should also be within the manufacturer's specifications.)

b. According to the bench test, the alternator is:

OK ___ NOT OK ___

If alternator is NOT OK, recommend steps to correct the situation.

8. If necessary, reinstall the alternator. For the proper procedure, refer to JS1-L1-UIX. __ __ __ __

9. Performance test the vehicle's charging system. For the proper procedure, refer to JS1-L1-UVIII. Record charging system output. __ __ __ __

Volts ___

Amps ___

Average of above evaluations* __ __ __ __

(*This average is a final evaluation for Competency G3.)

MODULE ELECTRICAL SYSTEMS

UNIT IX: INSPECTING, REPAIRING, AND REPLACING CHARGING SYSTEM COMPONENTS

UNIT IX TEST

SECTION A. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 1. Each vehicle manufacturer has a method of identifying the alternator as externally regulated.

____ 2. Most later-model vehicles use external regulators.

____ 3. If a vehicle's electrical load has been increased since its manufacture, an alternator with higher output may be required.

____ 4. Some charging systems use a computer-controlled relay to engage or disengage the field regulator circuit.

____ 5. An amp gauge is a mechanical device used to indicate resistance within charging system circuits.

____ 6. Always remove the ground cable from the battery before removing the battery lead on the alternator.

____ 7. A technician should never attempt to polarize an alternator.

____ 8. Most regulators are grounded by the radiator or steering column.

____ 9. Aluminum locking tabs ensure a fail-proof regulator connection.

____ 10. When performing a brush-holder test, the technician should verify that the brushes move smoothly and return halfway to the stops when released.

____ 11. A continuity test should indicate a closed circuit from one rotor slip ring to the other.

____ 12. A continuity test should indicate an open circuit from the stator leads to the frame.

____ 13. When testing a rectifier, the technician should check for continuity from the negative heat sink to each of the negative diode leads; the technician should then reverse the test probes and repeat the test. The result should show continuity in both directions.

SECTION B. Select the best answer from the five choices listed.

____ 14. Alternators in vehicles with gasoline engines use

a. external regulators only.
b. internal regulators only.
c. no regulators.
d. either an external or an internal regulator.
e. a regulator attached to either the starter or the catalytic converter.

____ 15. In alternators that use internal regulators, field control occurs inside the alternator by way of

a. another regulator.
b. a wound coil.
c. an iron bar.
d. a carbon pile.
e. electronic circuitry.

____ 16. The charging rate of an alternator is indicated by

a. a number stamped on the housing.
b. a metal tag attached to the housing screw.
c. paint dots on the alternator's housing.
d. any of the above.
e. none of the above.

____ 17. An alternator uses

a. either a V-belt or multirib pulley drive system.
b. neither a V-belt nor multirib pulley drive system.
c. a V-belt pulley drive system only.
d. a multirib drive system only.
e. both a V-belt and a multirib pulley drive system at the same time.

____ 18. If the rotor's field slip rings have minor damage, they can be dressed out with a

a. power sander.
b. coarse file.
c. fine emery cloth.
d. small chisel.
e. power grinder.

____ 19. The technician should inspect the stator for damage. One example of typical stator damage is

a. fluid leaks.
b. acid burns.
c. chipped protective paint.
d. broken leads.
e. cracks in the plastic housing.

____ 20. In order to control the charging rate, the external voltage regulator uses

a. magnetic coils.
b. transistors.
c. a diode bridge.
d. plastic insulation.
e. an iron bar.

(NOTE: The student must obtain a minimum score of ____ on the Unit IX Test in order to receive an evaluation for Competencies G2 and G3.)

ANSWERS TO UNIT IX TEST

1. t
2. f
3. t
4. t
5. f
6. t
7. t
8. f
9. f
10. f
11. t
12. t
13. f
14. d
15. e
16. d
17. a
18. c
19. d
20. a

MODULE: ELECTRICAL SYSTEMS

UNIT X: IDENTIFYING, DIAGNOSING, AND TESTING AUTOMOTIVE LIGHTING SYSTEMS

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose lighting system problems and determine needed repairs. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify terms and definitions associated with the lighting system (Competencies H1 and H2, Part I of the Unit X Test).

II. Identify lighting system components and circuits (Competencies H1 and H2, Part I of the Unit X Test).

III. Identify safety and warning light system components (Competencies H1 and H2, Part I of the Unit X Test).

Lesson 2. I. Identify general procedures for diagnosing and testing automotive lighting circuits (Competency H1, Part II of the Unit X Test).

II. Identify specific procedures for diagnosing and testing automotive lighting circuits (Competency H1, Part II of the Unit X Test).

III. Demonstrate the ability to:

a. Diagnose and test vehicle lighting systems (Competency H1, JS1-L2-UX).

b. Service headlights (Competency H1, JS2-L2-UX).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks F044, F045, F049, F051, F053, F055, F058, and F061. The job sheets can be adapted to cover ASE tasks F047 and F048.

MODULE: ELECTRICAL SYSTEMS

UNIT X: IDENTIFYING, DIAGNOSING, AND TESTING AUTOMOTIVE LIGHTING SYSTEMS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: IDENTIFYING AUTOMOTIVE LIGHTING SYSTEMS AND THEIR COMPONENTS

    a. Information outline

  2. Lesson 2: TESTING AND DIAGNOSING AUTOMOTIVE LIGHTING SYSTEMS

    a. Information outline

    b. Assignment sheets

      AS1-L2-UX: Procedure for Diagnosing and Testing Automotive Light Circuits

    c. Job sheets

      JS1-L2-UX: Diagnosing and Testing Automotive Light Circuits
      JS2-L2-UX: Servicing Automotive Headlights

E. Unit test

F. Answers to unit test

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NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Students should do AS1-L2-UX in conjunction with JS1-L2-UX.

MODULE: ELECTRICAL SYSTEMS

UNIT X: IDENTIFYING, DIAGNOSING, AND TESTING AUTOMOTIVE LIGHTING SYSTEMS

LESSON 1: IDENTIFYING AUTOMOTIVE LIGHTING SYSTEMS AND THEIR COMPONENTS

I. Terms and definitions

A. Actuator motor--An electrical drive motor that operates the concealed headlight assembly.

B. Backup light--A bulb designed to come on when a vehicle is put in reverse.

C. Concealed headlight--A headlight assembly that can be retracted flush to the hood surface when not in use.

D. Contact switch--A switch that is activated by pushing or pulling on the switch mechanism. A contact switch is identified as either normally open (no) or normally closed (nc).

E. Control device--Any mechanical or electromechanical device that controls current flow in a circuit.

F. Digital indicators--An electronic or liquid crystal device designed to convey either a warning or other important information to the driver.

G. Dimmer switch--An electromechanical or mechanical device that switches headlights from high to low beam.

H. Fiber optics--A plastic or glass filament that transports light.

I. Filament--The central core of an incandescent bulb. The filament glows upon receiving current.

J. Grounding switch--A switch that completes a circuit by grounding it to a vehicle's chassis or B- terminal.

K. Halogen headlight--A sealed-beam light that houses a smaller inner bulb, containing halogen gas and a tungsten filament.

L. Hazard system--A set of flashing lights which receive electrical current from the turn signal system.

M. Headlight--A sealed-beam light used to illuminate the road in front of a vehicle

N. Incandescent lamp--Any light that uses a glowing filament as a source of illumination.

O. Load device--Any device that requires electrical current to function.

P. Side-marker lights--Lights located on the sides of a vehicle. Side-marker lights increase a vehicle's visibility.

Q. Stop warning light--A light fed through the turn signal circuit. A stop warning light indicates that the vehicle is stopping.

R. Taillights/parking lights--Warning lights used to increase a vehicle's visibility.

II. Lighting system components and circuits

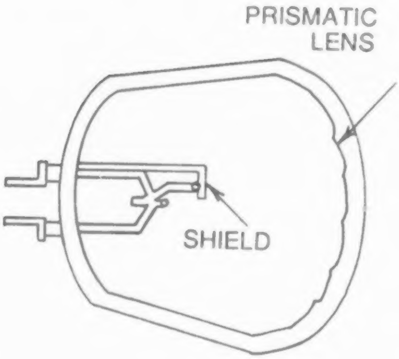
A. Headlights

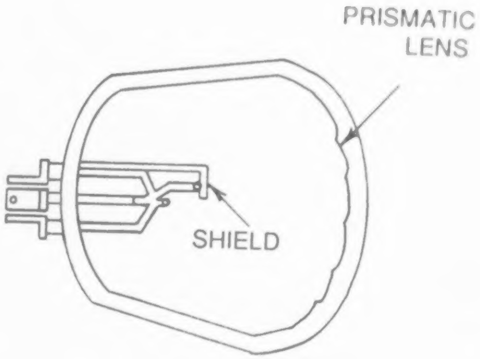
1. Headlights use sealed-beam bulbs. The filament of a sealed-beam bulb is housed in a sealed, gas-filled chamber.

2. In vehicles with four-light systems, single-filament headlights provide high-beam light.

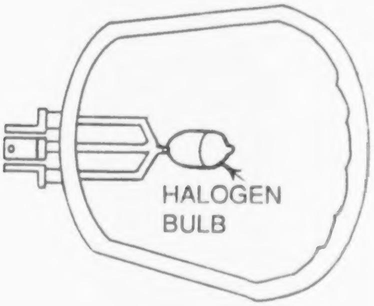
3. Double filament headlights provide high and low-beam light in both two and four-light systems. A selection switch (called a dimmer switch) provides current to one or both filaments (thus providing either high or low-beam light).

4. A few manufacturers use three-filament headlights. When two of the filaments burn out, power is provided to the third, which then produces enough light for the driver to proceed with caution.

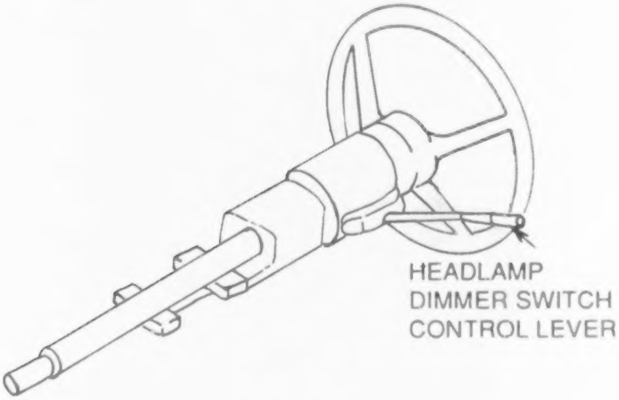




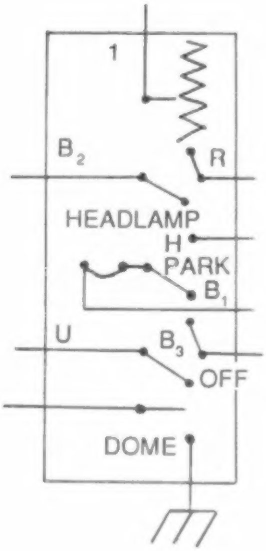
5. A Halogen headlight uses a brightly burning tungsten filament, contained in a halogen-filled bulb.

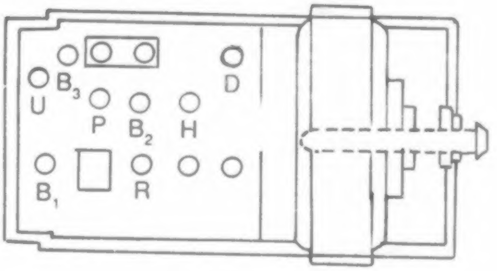

HALOGEN
BULB

6. The headlight dimmer switch is either a mechanical or relay device, which determines what filament will receive current (thus providing high and low-beam light).

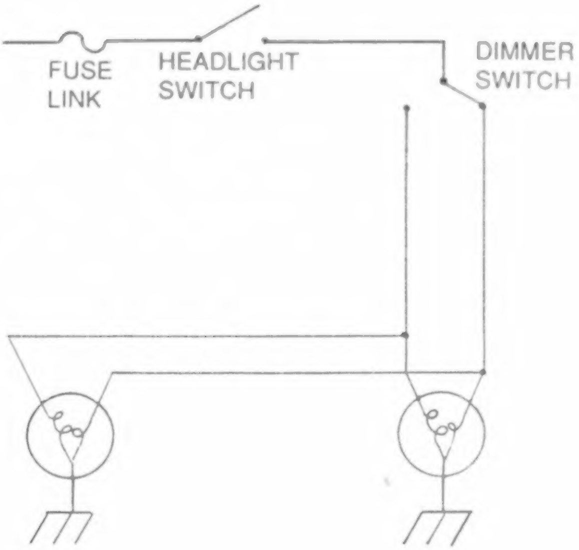

HEADLAMP
DIMMER SWITCH
CONTROL LEVER

7. A headlight switch is a multiple pole contact switch, which can operate several lighting circuits (depending on the switch position).

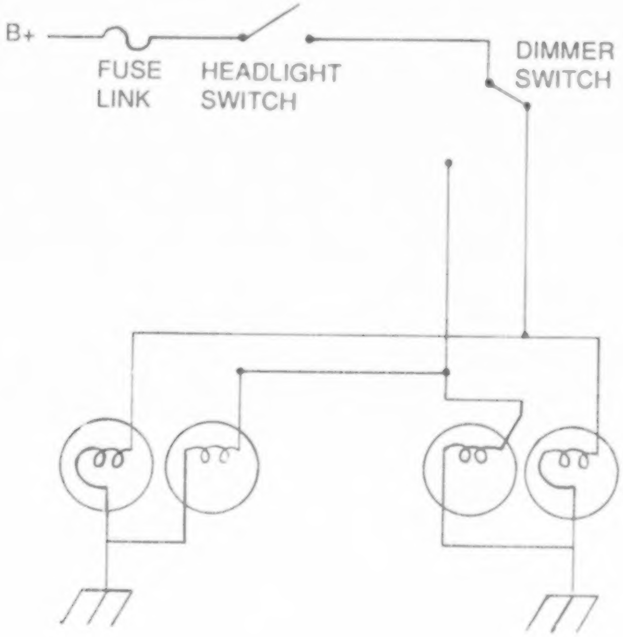

1
B_2
R
HEADLAMP
H
PARK
B_1
U
B_3
OFF
DOME


B_3
U
D
P
B_2
H
B_1
R

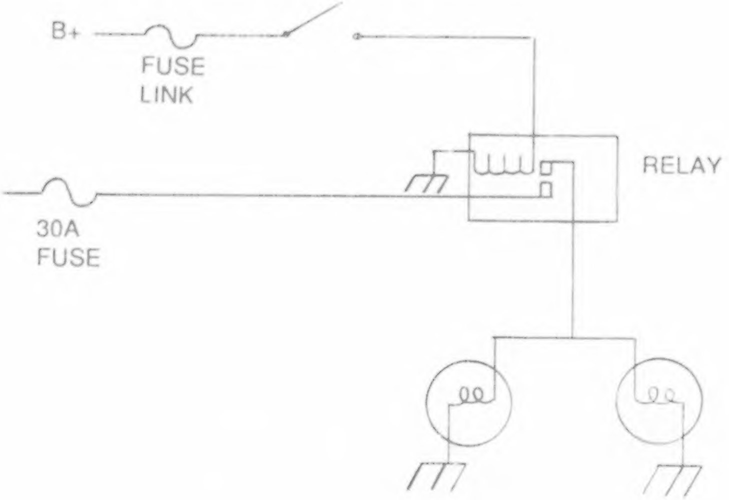
8. In a two-headlight system, the high and low-beam filaments are in parallel.


FUSE LINK
HEADLIGHT SWITCH
DIMMER SWITCH

9. In a four-headlight system, an additional bulb with a single filament is in parallel to the high-beam circuit.

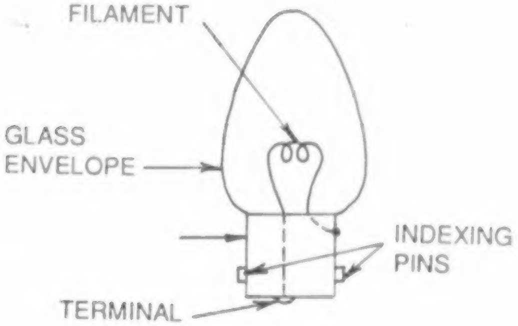

B+
FUSE LINK
HEADLIGHT SWITCH
DIMMER SWITCH

10 In some systems, a relay is used to operate the headlight circuit.

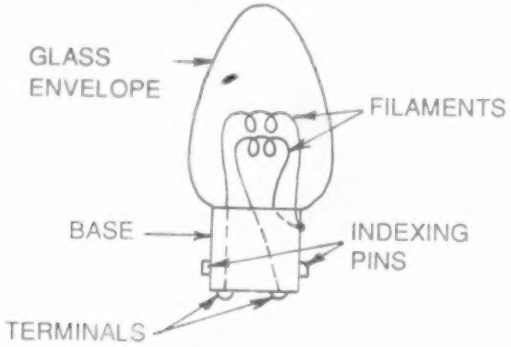

B+
FUSE LINK
RELAY
30A FUSE

B. Tail and park lights

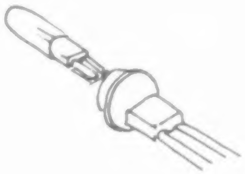
1. Single-filament bulbs are used as interior lights, back-up lights, or side marker lights.


FILAMENT
GLASS ENVELOPE
INDEXING PINS
TERMINAL

2. Double-filament bulbs can be used as a taillight or turn signal light/brake lights. One filament is wired to the taillight circuit while the other is wired to the turn signal circuit.


GLASS ENVELOPE
FILAMENTS
BASE
INDEXING PINS
TERMINALS

3. A side marker is a warning light mounted on the vehicle's side. To allow it to flash with the turn signal, a side marker is sometimes connected across the turn signal and taillight circuit.

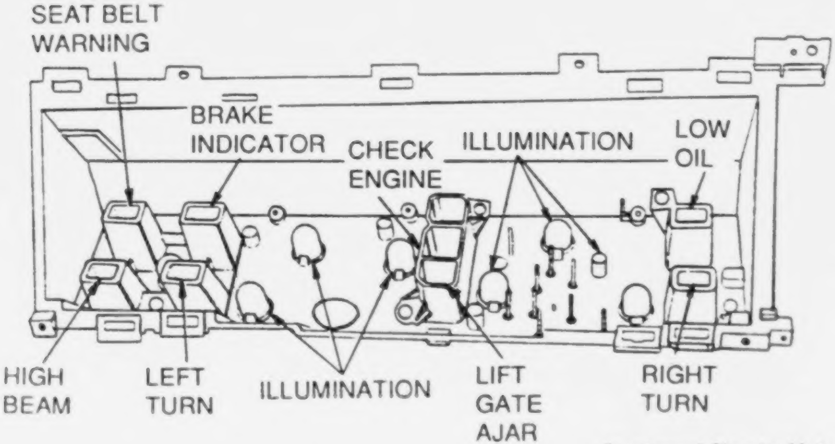


4. The taillights, side marker lights, and parking lights are controlled by the headlight switch.

C. Dash lights

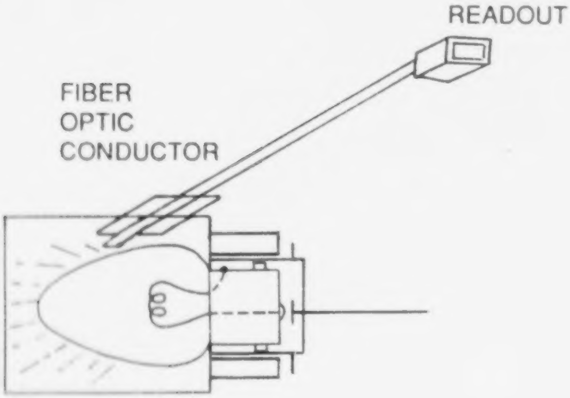
1. The dash is illuminated by standard incandescent bulbs, which are activated by the headlight switch.

   (NOTE: Most vehicles have a rheostat in the headlight switch. The rheostat varies the flow of current to the dash lights and thus controls their brightness.)

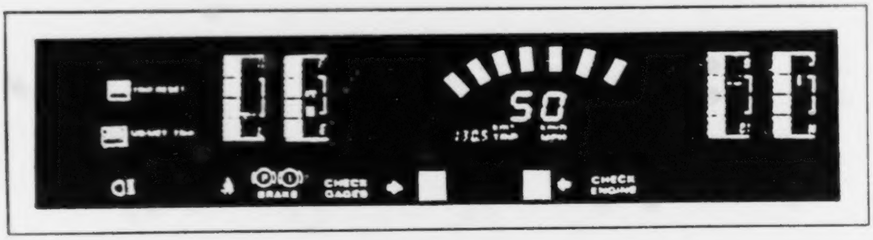

SEAT BELT WARNING
BRAKE INDICATOR
CHECK ENGINE
ILLUMINATION
LOW OIL
HIGH BEAM
LEFT TURN
ILLUMINATION
LIFT GATE AJAR
RIGHT TURN

Courtesy of Chrysler Motors

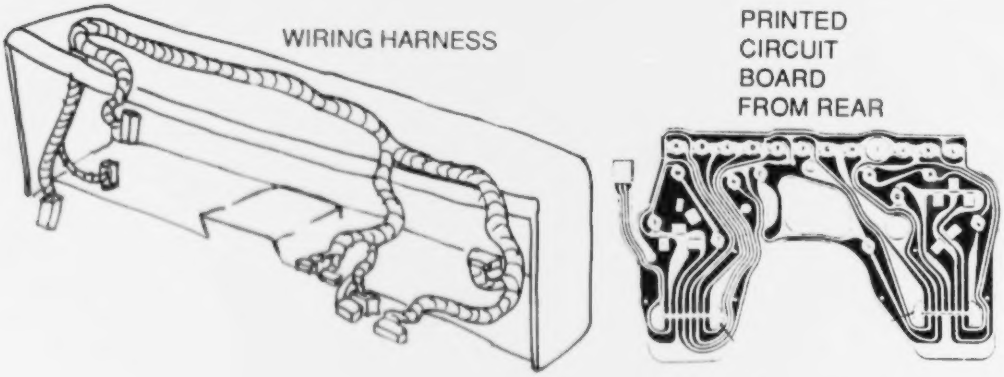
2. Fiber optics (plastic fiber filaments) can transport light from a remote source to a portion of the dash that contains no incandescent bulb.


READOUT
FIBER OPTIC CONDUCTOR

3. Some vehicles have electronic dashes, containing digital read-out gauges and indicators. Digital gauges and indicators produce their own light and thus are not illuminated by an external source.


50
BRAKE
CHECK GAGES
CHECK ENGINE

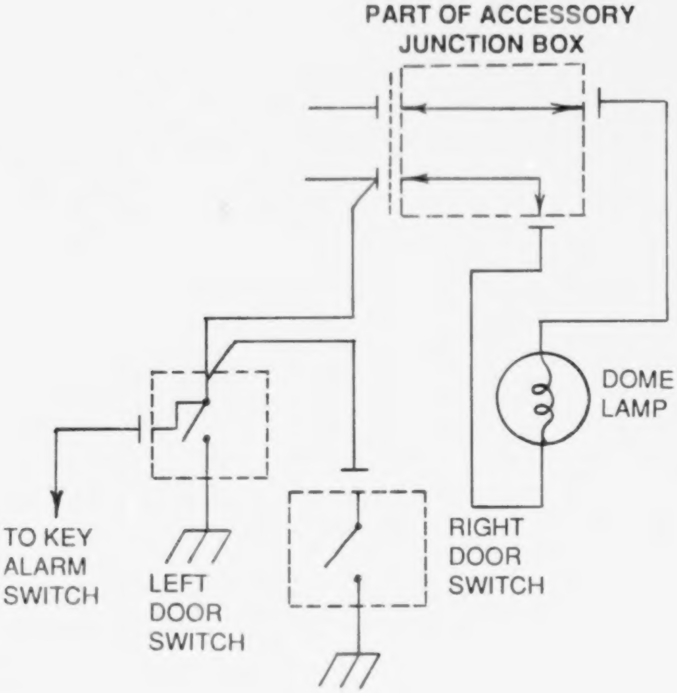
4. Either traditional stranded wire or a printed circuit board supplies current to dash lights.


WIRING HARNESS
PRINTED CIRCUIT BOARD FROM REAR

Courtesy of General Motors Corporation

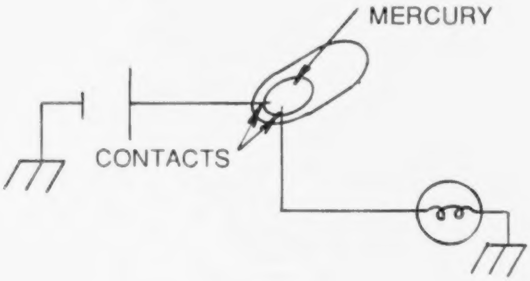
D. Courtesy light systems

1. Courtesy lights illuminate a vehicle's passenger, trunk, and engine compartments. Some courtesy light systems use a grounding switch circuit. In this circuit, power is supplied through the bulb and continues on to the grounding switch. When the switch (which is normally open) closes, the circuit is grounded and the courtesy lights come on.


PART OF ACCESSORY JUNCTION BOX
DOME LAMP
TO KEY ALARM SWITCH
LEFT DOOR SWITCH
RIGHT DOOR SWITCH

2. In the contact switch circuit, the switch prevents current from flowing through the bulb and onto ground.

3. Some courtesy light systems use a mercury switch circuit. A mercury switch is a vial containing a small bubble of mercury. The circuit leads enter at one end of the chamber. When the vial is tilted, the mercury collects in the end with the leads, thus completing the circuit and lighting the bulb.

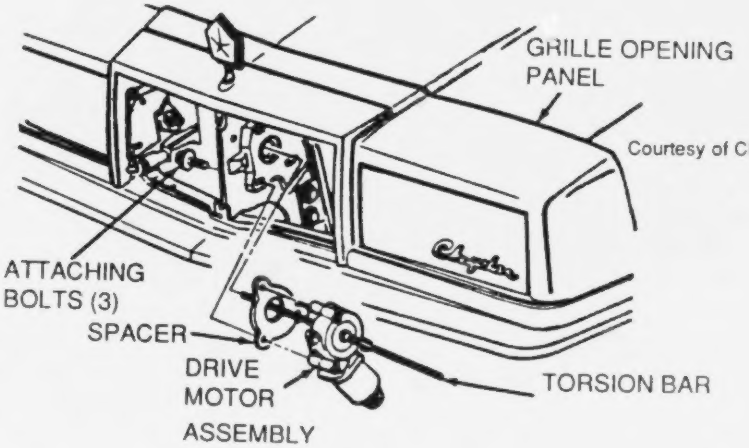

MERCURY
CONTACTS

4. Other courtesy light systems use a timer relay to keep the circuit energized a few seconds after the vehicle's doors are closed. In most cases the timer will be either a solid-state or capacitor-discharge device.

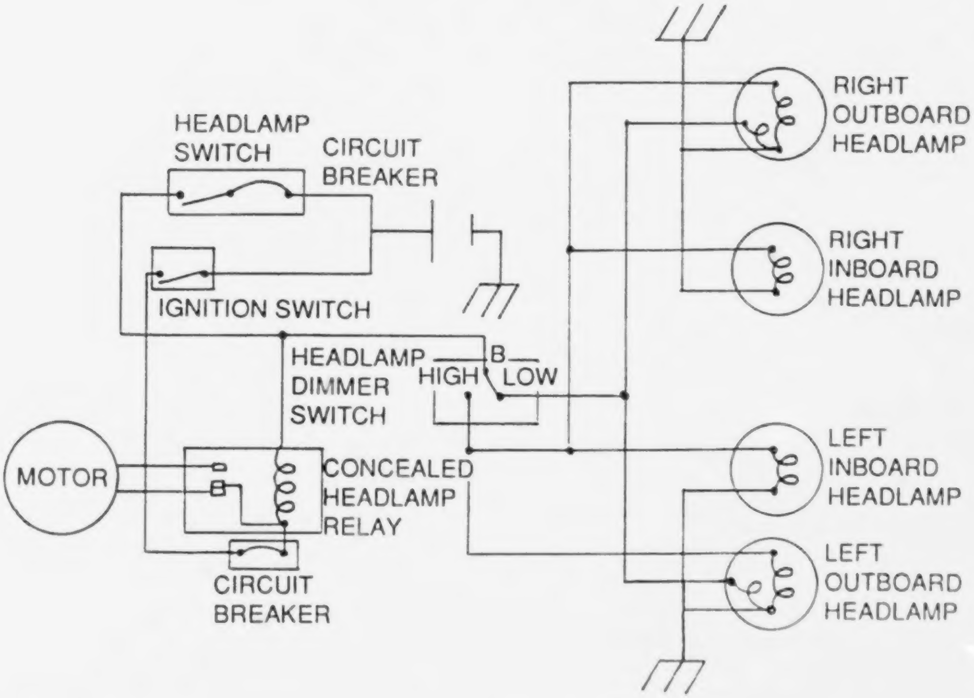
(NOTE: A courtesy light timer is usually a small plastic box located under the vehicle's dash.)

E. Concealed headlight systems

1. On some vehicles, concealed headlight doors are driven by an actuator motor, which is controlled by the headlight switch and a relay. When the headlight switch is turned on, the relay is activated, causing the actuator motor to open the headlight doors. A cycling switch steps the motor at the correct point.


GRILLE OPENING PANEL
ATTACHING BOLTS (3)
SPACER
DRIVE MOTOR ASSEMBLY
TORSION BAR

Courtesy of Chrysler Motors

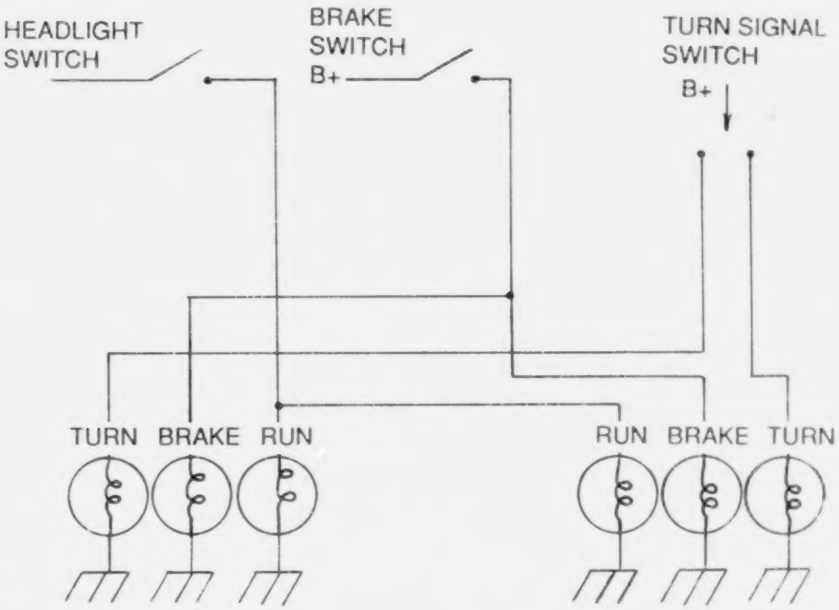

HEADLAMP SWITCH
CIRCUIT BREAKER
IGNITION SWITCH
HEADLAMP DIMMER SWITCH
B
HIGH
LOW
MOTOR
CONCEALED HEADLAMP RELAY
CIRCUIT BREAKER
RIGHT OUTBOARD HEADLAMP
RIGHT INBOARD HEADLAMP
LEFT INBOARD HEADLAMP
LEFT OUTBOARD HEADLAMP

2. Other vehicles use a vacuum motor to drive concealed headlight doors. When the headlight switch is turned on, a vacuum causes the motor to rotate, thus opening the headlight doors.

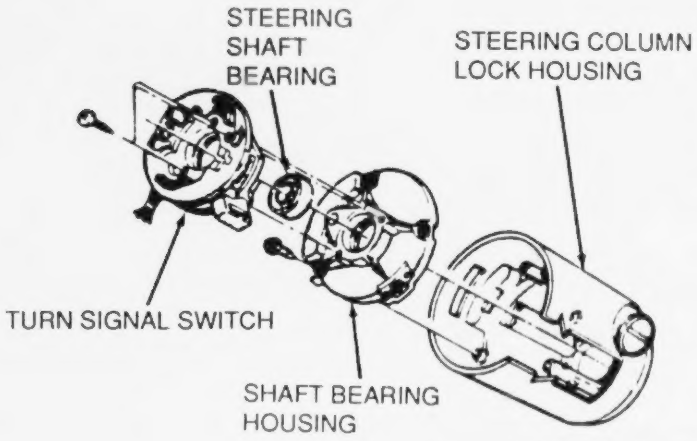
III. Safety and warning light system components

A. Stop lights and turn signals

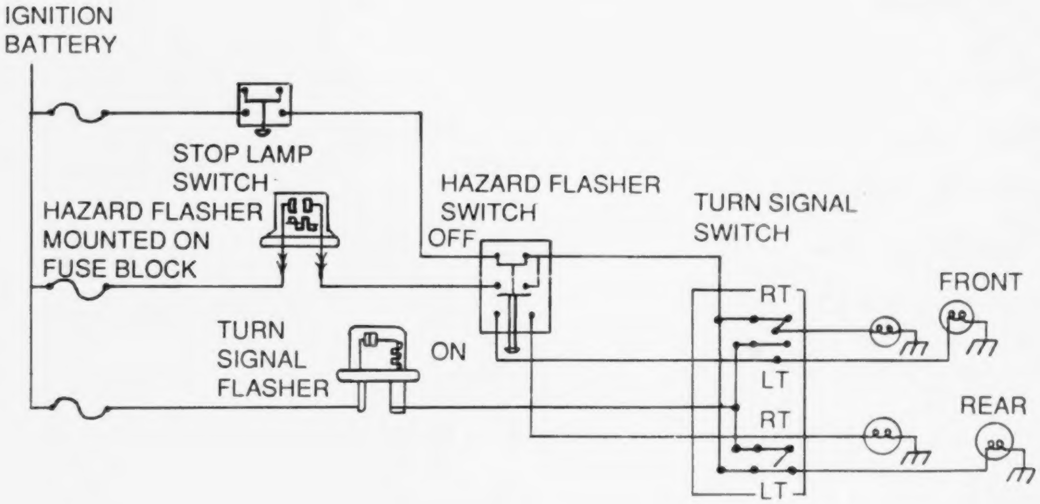
1. Double and single-filament systems


HEADLIGHT SWITCH
BRAKE SWITCH
B+
TURN SIGNAL SWITCH
B+
TURN
BRAKE
RUN
RUN
BRAKE
TURN

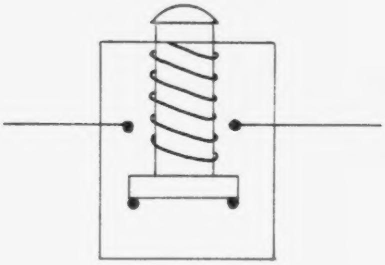
2. The turn signal switch performs a dual role. While connecting the turn signal flasher to the appropriate signal light circuit, the switch simultaneously cancels (eliminates) the flasher circuit from the opposite rear signal light circuit and connects the brake pedal switch to the cancelled circuit. If the brakes are applied during turn signal operation, the bulb in the cancelled signal circuit will glow until the pedal is released.


STEERING SHAFT BEARING
STEERING COLUMN LOCK HOUSING
TURN SIGNAL SWITCH
SHAFT BEARING HOUSING

Courtesy of Chrysler Motors

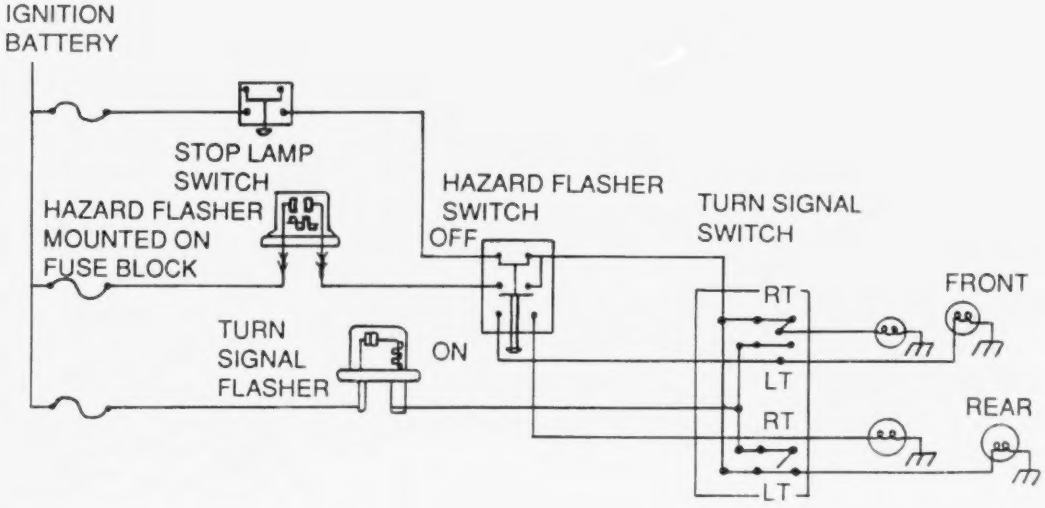

IGNITION BATTERY
STOP LAMP SWITCH
HAZARD FLASHER MOUNTED ON FUSE BLOCK
HAZARD FLASHER SWITCH
OFF
ON
TURN SIGNAL FLASHER
TURN SIGNAL SWITCH
RT
LT
RT
LT
FRONT
REAR

3. The brake switch remains open until it is contacted as a result of brake pedal application.



4. Hazard lights use a different flasher than the turn signals. The hazard lights are activated by their own switch; however, the hazard light switch uses the turn signal circuit to connect all four bulbs at the same time.

5. Circuit arrangement for brake, turn, and hazard circuits


IGNITION
BATTERY
STOP LAMP
SWITCH
HAZARD FLASHER
MOUNTED ON
FUSE BLOCK
HAZARD FLASHER
SWITCH
OFF
ON
TURN SIGNAL
SWITCH
TURN
SIGNAL
FLASHER
RT
LT
RT
LT
FRONT
REAR

B. Backup lights

1. Some backup lights use a contact switch mounted on or in the transmission. This switch is activated by either the movement of the transmission linkage or the transmission fluid.

2. Other backup lights use a contact switch mounted on the steering column. The switch is activated when the gear selector is placed in the "reverse" position. The switch may be a part of the neutral safety switch.

MODULE: ELECTRICAL SYSTEMS

UNIT X: IDENTIFYING, DIAGNOSING, AND TESTING AUTOMOTIVE LIGHTING SYSTEMS

LESSON 2: TESTING AND DIAGNOSING AUTOMOTIVE LIGHTING SYSTEMS

I. Basic information concerning the testing and diagnosing of lighting system components

  A. Lighting circuit components fall into three categories: load device, control device, and load-control device.

  B. Testing a load device

    1. Equipment for testing a load device

      a. The self-powered test light has its own battery. The light can, therefore, supply current to a load device in order to test it for continuity.

      b. An ohmmeter should be used to determine the exact resistance of a load device. The ohmmeter has its own battery and can, therefore, supply current to a load in order to test it for resistance. Thoguh a load should have some resistance, its resistance should not be infinite.

      c. Jumper leads can supply current to a load, thus allowing the load to be tested while out of circuit. During such a test, the load's operating voltage and polarity must be observed.

    2. Procedure for testing a load device with a self-powered test light

      a. Using a wiring diagram, determine if the load device truly is a load. (Remember that a load requires current in order to function.)

      b. Disconnect the load device from the circuit.

      c. Connect the self-powered test light in series with the load device.

      d. The self-powered test light will be illuminated if the load device has continuity.

      (NOTE: If the resistance of the load device is greater than the potential voltage of the self-powered test light, the test light will not come on.)

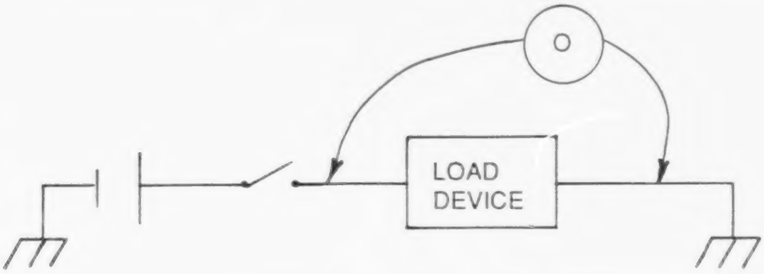
    3. Procedure for testing a load device with an ohmmeter

      a. Using a wiring diagram, determine if the load device truly is a load. (Remember that a load requires current in order to function.)

      b. Disconnect the load device from the circuit.

      c. Place ohmmeter in RX1 and connect leads in parallel across the load.

d. Ohmmeter reading should be more than 0 but not infinite.



4. Procedure for testing a load device with a jumper lead.

   a. Using a wiring diagram, determine if the load device truly is a load. (Remember that a load requires current in order to function.)

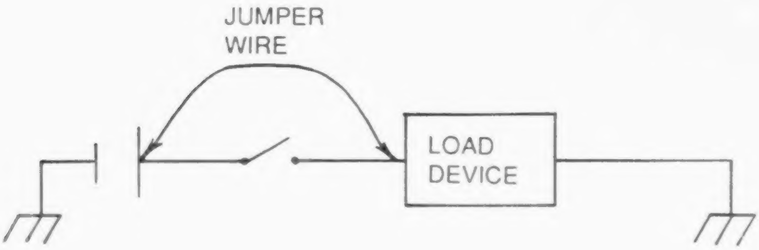
   b. Disconnect the load device from the circuit.

   c. Locate the terminal for battery current and attach a jumper lead to it.

   d. Locate the terminal for battery ground and attach another jumper lead to it.

   e. Connect jumper leads to a battery to operate the load.

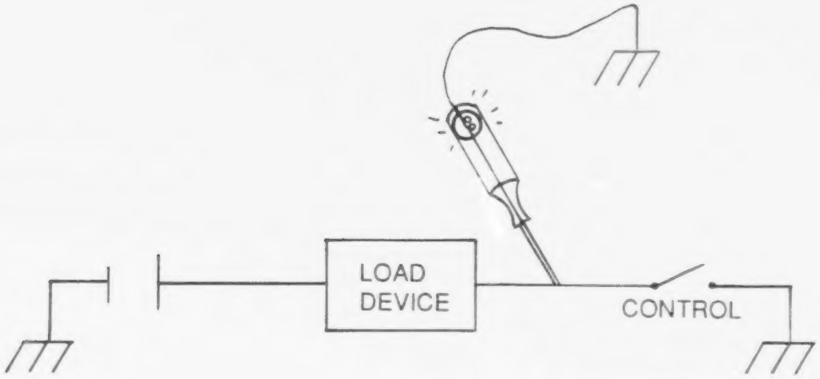
   (**CAUTION**: Care must be taken to observe voltage and polarity.)



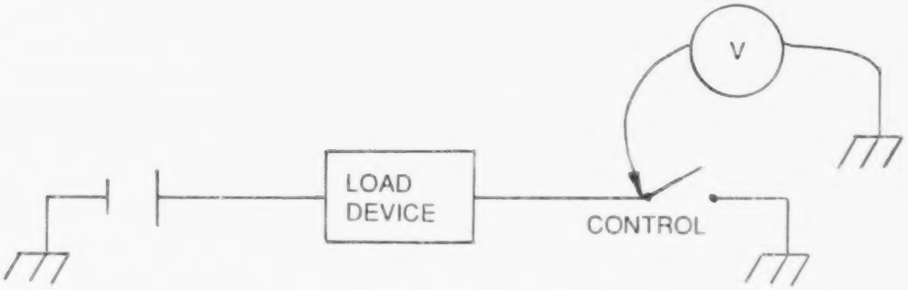
C. Testing a control device

1. A control device merely switches current on or off. Control devices can be tested either in or out of the circuit.

   a. A test light can be used to check for current before and after the control activity by connecting the light in the circuit or in parallel to the circuit.



b. A voltmeter can accomplish the same task as a test light. The voltmeter is preferable because it gives a reading which indicates how much voltage is available at a particular point in the circuit.



2. Procedure for in-circuit testing of control devices

   a. Using a wiring diagram, locate the battery supply terminal and the controlled circuit terminal (which may be ground).

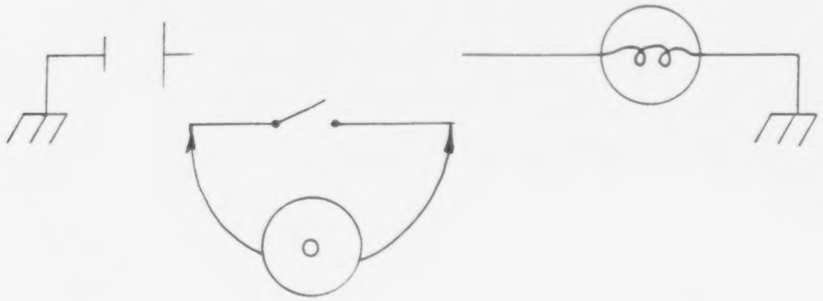
   b. Probe the terminal block with a test light or voltmeter lead (select scale).

   c. Connect other lead to ground.

   d. Energize circuit and activate switch (control device). After doing so, the test light should come on or the voltmeter should give an appropriate reading.

3. Procedure for out-of-circuit testing of a control device

   a. An ohmmeter is required to test a control device out of its circuit.



   b. Disconnect the control device from the circuit.

   c. Using a wiring diagram, locate the battery supply terminal and the circuit terminal.

   d. Connect ohmmeter across control device in parallel to the terminals.

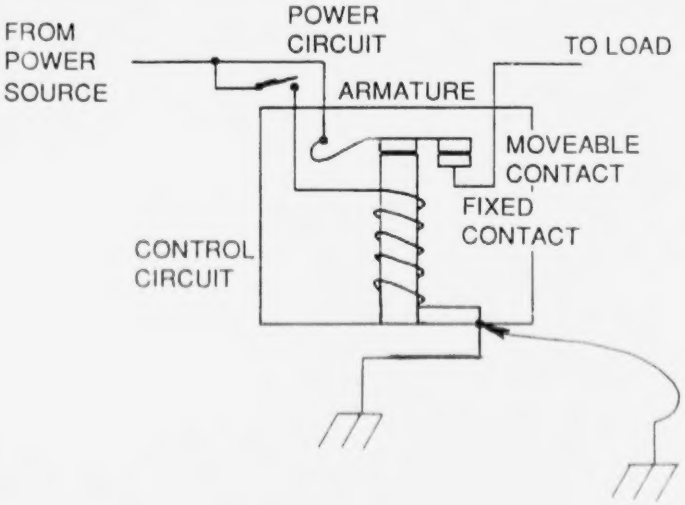
   e. Activate control device. After doing so, meter should give appropriate 0 and infinite readings.

   (NOTE: A self-powered test light can also be used to test control devices when they are removed from the circuit.)

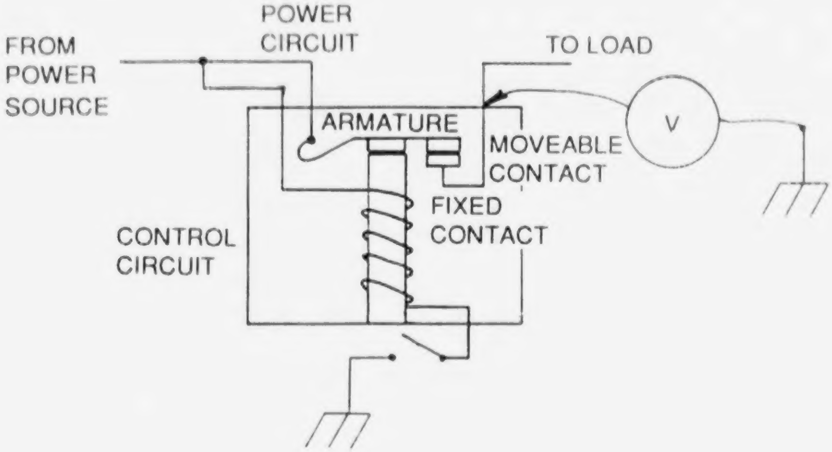
D. Testing an electromechanical relay

   1. An electromechanical relay requires current in order to function. An electromechanical relay is an example of a load-control device. The internal coil of the relay requires current to function and its electromagnetic activity causes the contacts inside to open or close.

a. Power side switched electromechanical relays

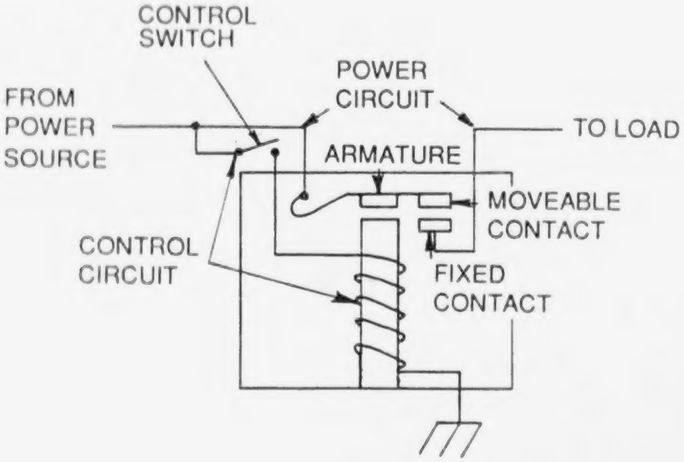

FROM
POWER
SOURCE
POWER
CIRCUIT
TO LOAD
ARMATURE
MOVEABLE
CONTACT
FIXED
CONTACT
CONTROL
CIRCUIT

b. Ground-side switched electromechanical relays

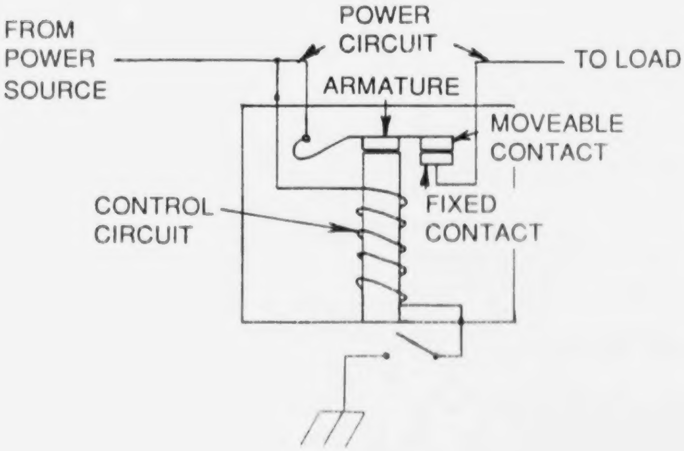

FROM
POWER
SOURCE
POWER
CIRCUIT
TO LOAD
ARMATURE
V
MOVEABLE
CONTACT
FIXED
CONTACT
CONTROL
CIRCUIT

2. To test the relay (load-control device), the technician may combine the control and load test procedures discussed above. During testing, the relay may be activated from a remote source or allowed to function in its circuit.

a. When activating a relay from a remote source with the circuit on, use a jumper wire to ground the coil terminal. Doing so will test relay operation.


CONTROL SWITCH
FROM POWER SOURCE
POWER CIRCUIT
TO LOAD
ARMATURE
MOVEABLE CONTACT
CONTROL CIRCUIT
FIXED CONTACT

b. When testing the load-control device while in circuit, operate the relay and test for the presence of battery voltage at the appropriate points.

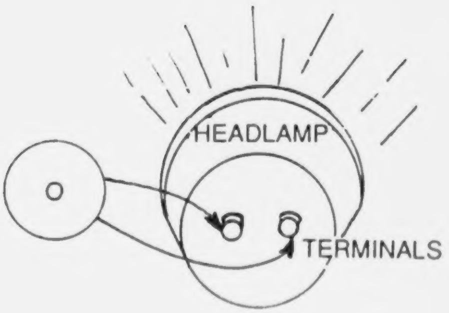

FROM POWER SOURCE
POWER CIRCUIT
TO LOAD
ARMATURE
MOVEABLE CONTACT
CONTROL CIRCUIT
FIXED CONTACT

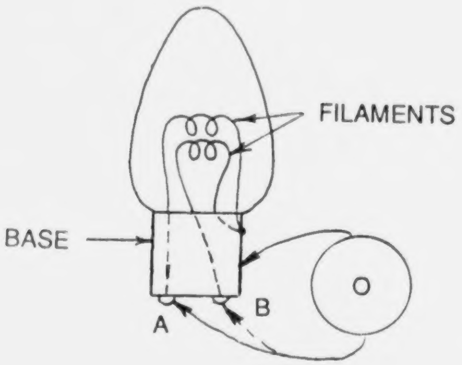
II. Specific testing and diagnostic procedures for an automotive lighting system

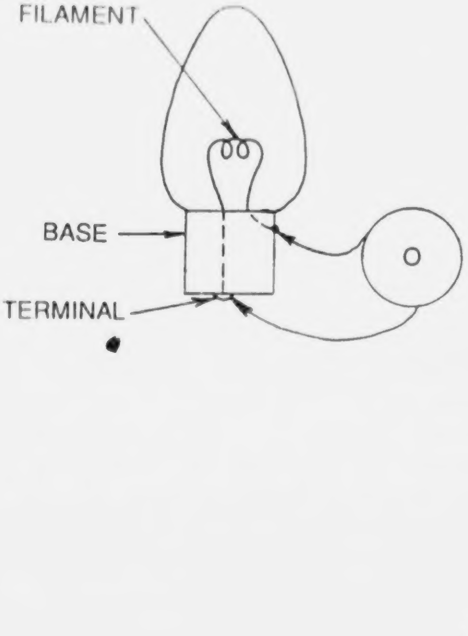
A. Testing an automotive light bulb (load)

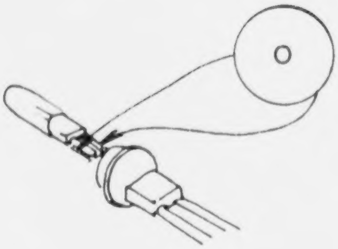
1. Use either an ohmmeter or jumper wires (with battery) to confirm that the light bulb filament has continuity.

a. Below is an example of an ohmmeter being used to test a light bulb.

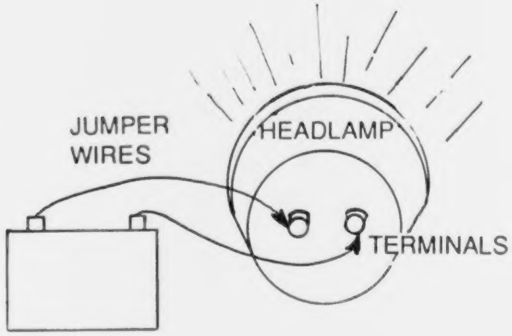

O
HEADLAMP
TERMINALS


FILAMENTS
BASE
O
A
B

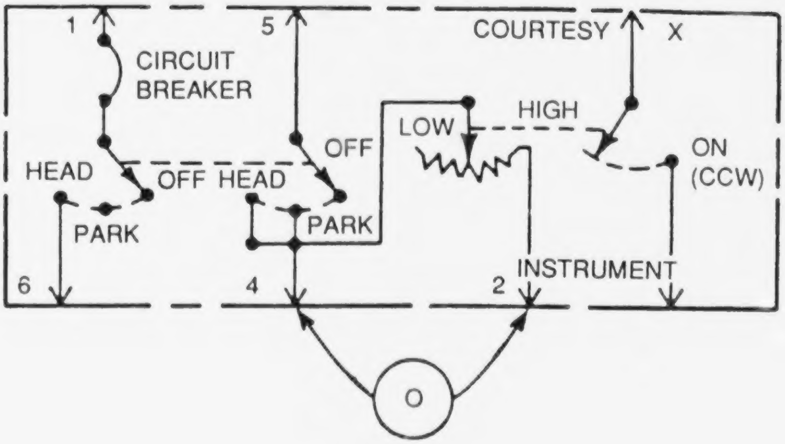

FILAMENT
BASE
O
TERMINAL



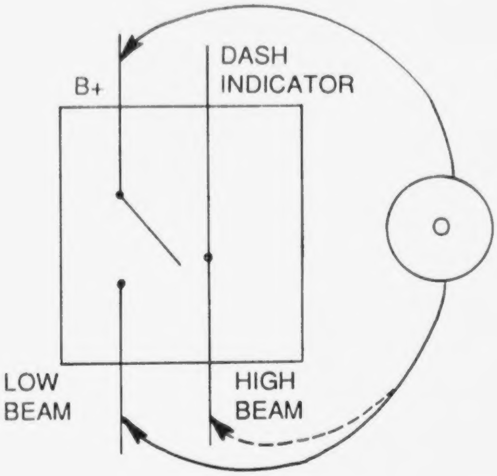
b. Below is an example of jumper wires (with battery) being used to test a light bulb.


JUMPER WIRES
HEADLAMP
TERMINALS

2. Use an ohmmeter to confirm that the different switch circuits function properly.

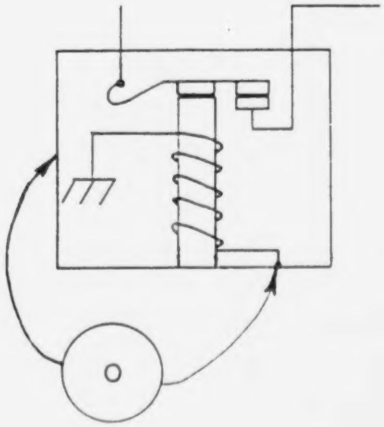

1
5
COURTESY
X
CIRCUIT BREAKER
HIGH
LOW
OFF
ON (CCW)
HEAD
OFF
HEAD
PARK
PARK
INSTRUMENT
6
4
2
O

3. Use an ohmmeter to confirm continuity in a dimmer switch

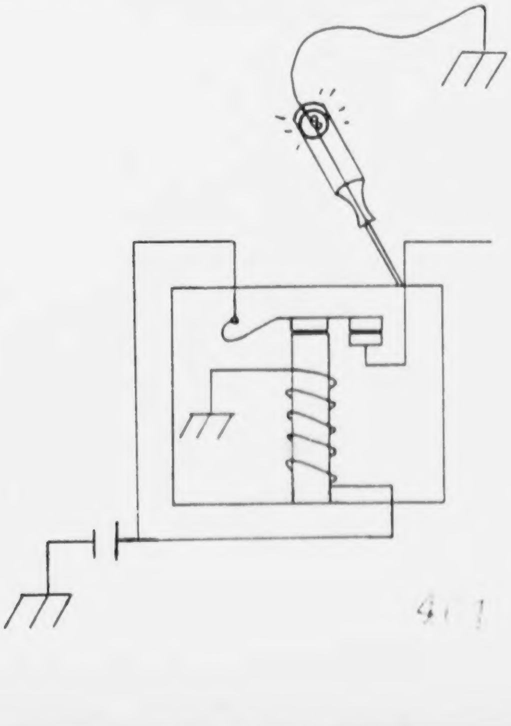

DASH INDICATOR
B+
O
LOW BEAM
HIGH BEAM

4. Headlight relay (load control)

   a. Use a test light and jumper wires (with battery) to confirm continuity in the headlight relay while the relay is in its circuit.

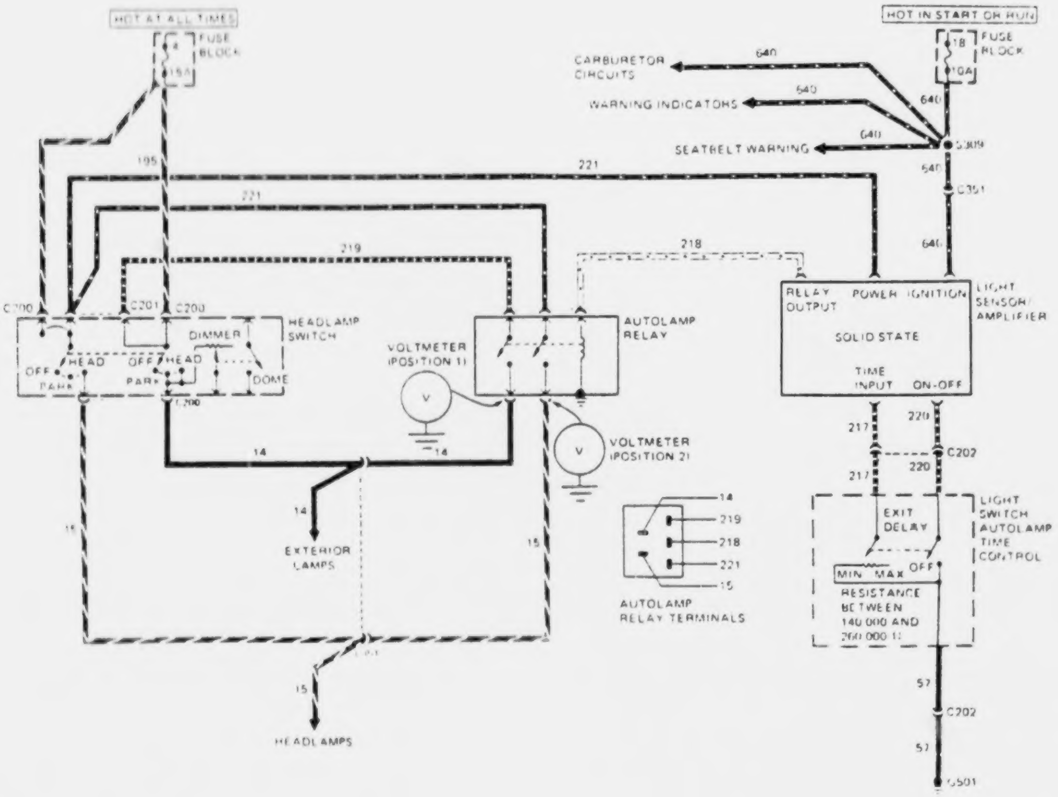


   b. Use either an ohmmeter or self-powered test light to confirm continuity in the headlight relay while the relay is out of its circuit.



B. Courtesy light system

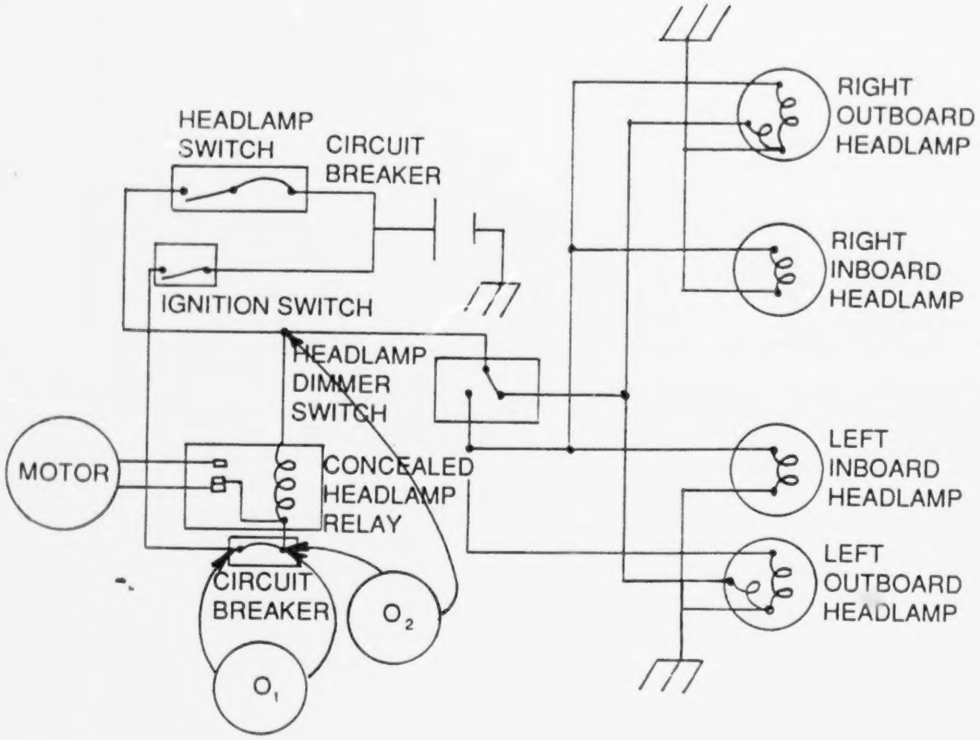
1. Bulb (load)
2. Switch (control)
3. Timer delay (load-control)


HOT AT ALL TIMES
FUSE BLOCK
4
15A
195
221
221
219
218
C200
C201
C200
HEADLAMP SWITCH
DIMMER
OFF
HEAD
PARK
OFF
HEAD
PARK
DOME
C200
VOLTMETER (POSITION 1)
V
AUTOLAMP RELAY
VOLTMETER (POSITION 2)
V
14
14
14
EXTERIOR LAMPS
15
15
15
HEADLAMPS
HOT IN START OR RUN
FUSE BLOCK
18
10A
640
CARBURETOR CIRCUITS
640
WARNING INDICATORS
640
SEATBELT WARNING
640
S309
640
C351
640
RELAY OUTPUT
POWER
IGNITION
LIGHT SENSOR/ AMPLIFIER
SOLID STATE
TIME INPUT
ON-OFF
217
220
C202
217
220
14
219
218
221
15
AUTOLAMP RELAY TERMINALS
EXIT DELAY
LIGHT SWITCH AUTOLAMP TIME CONTROL
MIN MAX
OFF
RESISTANCE BETWEEN 140 000 AND 260 000 Ω
57
C202
57
G501

Courtesy of Ford Motor Company

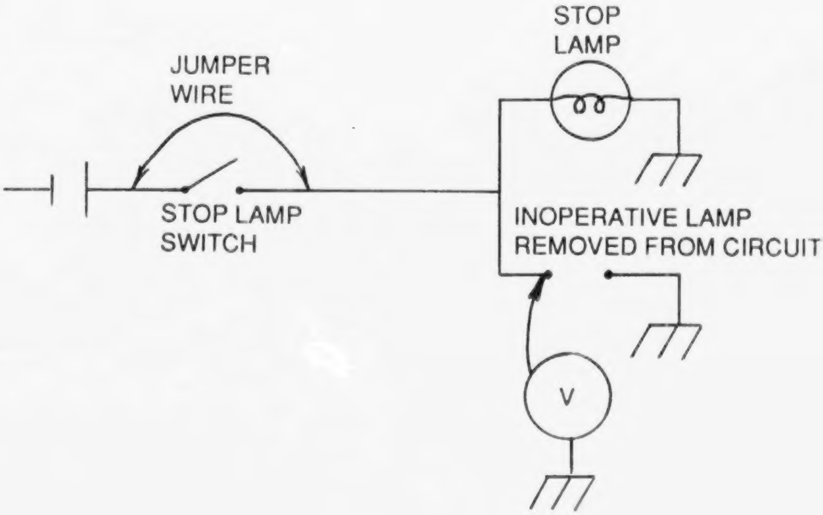
C. Concealed headlights

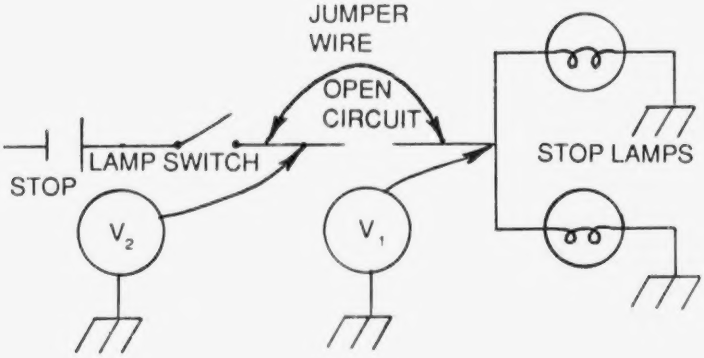
1. Motor (load control)
2. Switch (load)


HEADLAMP SWITCH
CIRCUIT BREAKER
IGNITION SWITCH
HEADLAMP DIMMER SWITCH
MOTOR
CONCEALED HEADLAMP RELAY
CIRCUIT BREAKER
O_1
O_2
RIGHT OUTBOARD HEADLAMP
RIGHT INBOARD HEADLAMP
LEFT INBOARD HEADLAMP
LEFT OUTBOARD HEADLAMP

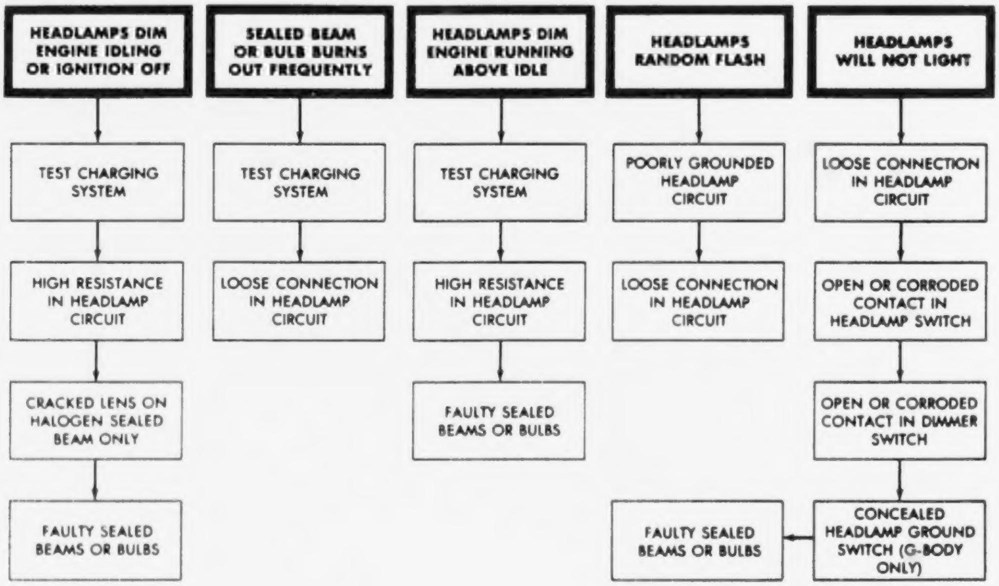
D. Stop and turn signal

1. Bulb
2. Turn signal switch (control)
3. Stop light switch (control)
4. Hazard switch (control)
5. Flasher (load control)


STOP
LAMP
JUMPER
WIRE
STOP LAMP
SWITCH
INOPERATIVE LAMP
REMOVED FROM CIRCUIT
V

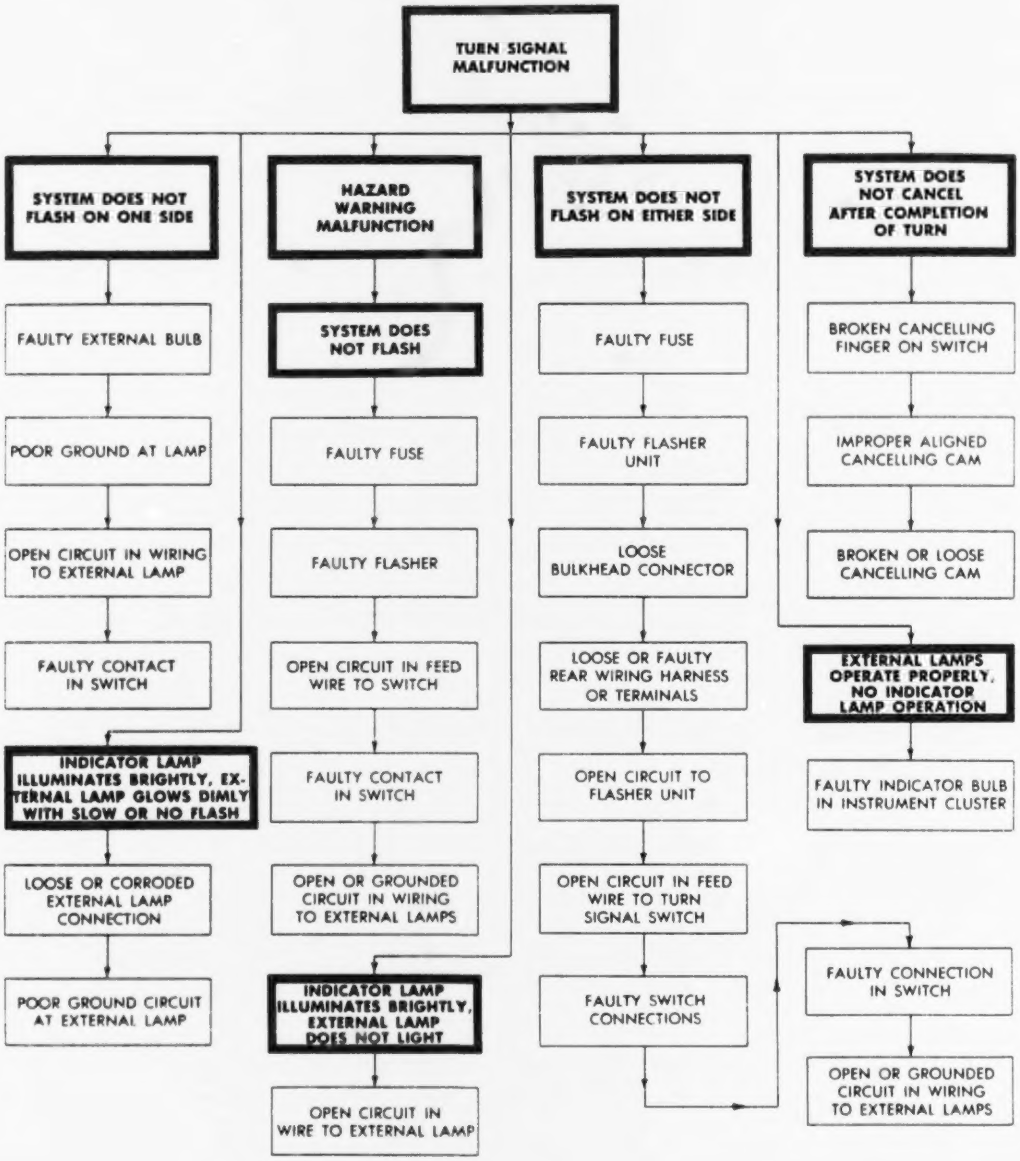

JUMPER
WIRE
OPEN
CIRCUIT
STOP LAMPS
STOP
LAMP SWITCH
V_2
V_1

E. Headlight trouble shooting chart


HEADLAMPS DIM ENGINE IDLING OR IGNITION OFF
TEST CHARGING SYSTEM
HIGH RESISTANCE IN HEADLAMP CIRCUIT
CRACKED LENS ON HALOGEN SEALED BEAM ONLY
FAULTY SEALED BEAMS OR BULBS
SEALED BEAM OR BULB BURNS OUT FREQUENTLY
TEST CHARGING SYSTEM
LOOSE CONNECTION IN HEADLAMP CIRCUIT
HEADLAMPS DIM ENGINE RUNNING ABOVE IDLE
TEST CHARGING SYSTEM
HIGH RESISTANCE IN HEADLAMP CIRCUIT
FAULTY SEALED BEAMS OR BULBS
HEADLAMPS RANDOM FLASH
POORLY GROUNDED HEADLAMP CIRCUIT
LOOSE CONNECTION IN HEADLAMP CIRCUIT
HEADLAMPS WILL NOT LIGHT
LOOSE CONNECTION IN HEADLAMP CIRCUIT
OPEN OR CORRODED CONTACT IN HEADLAMP SWITCH
OPEN OR CORRODED CONTACT IN DIMMER SWITCH
CONCEALED HEADLAMP GROUND SWITCH (G-BODY ONLY)
FAULTY SEALED BEAMS OR BULBS

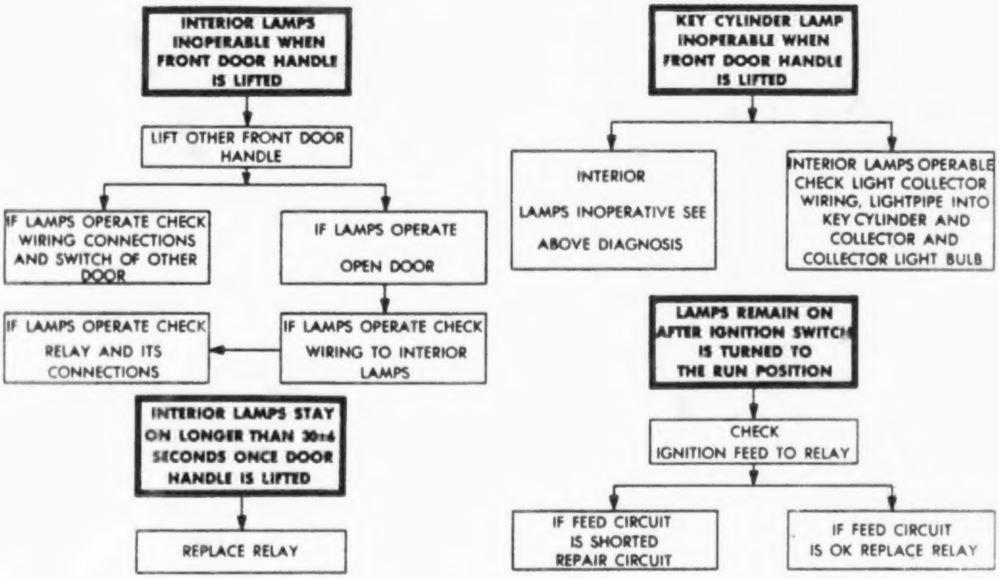
Courtesy of Chrysler Motors

F. Turn signal and hazard light trouble shooting chart


TURN SIGNAL MALFUNCTION
SYSTEM DOES NOT FLASH ON ONE SIDE
FAULTY EXTERNAL BULB
POOR GROUND AT LAMP
OPEN CIRCUIT IN WIRING TO EXTERNAL LAMP
FAULTY CONTACT IN SWITCH
INDICATOR LAMP ILLUMINATES BRIGHTLY, EXTERNAL LAMP GLOWS DIMLY WITH SLOW OR NO FLASH
LOOSE OR CORRODED EXTERNAL LAMP CONNECTION
POOR GROUND CIRCUIT AT EXTERNAL LAMP
HAZARD WARNING MALFUNCTION
SYSTEM DOES NOT FLASH
FAULTY FUSE
FAULTY FLASHER
OPEN CIRCUIT IN FEED WIRE TO SWITCH
FAULTY CONTACT IN SWITCH
OPEN OR GROUNDED CIRCUIT IN WIRING TO EXTERNAL LAMPS
INDICATOR LAMP ILLUMINATES BRIGHTLY, EXTERNAL LAMP DOES NOT LIGHT
OPEN CIRCUIT IN WIRE TO EXTERNAL LAMP
SYSTEM DOES NOT FLASH ON EITHER SIDE
FAULTY FUSE
FAULTY FLASHER UNIT
LOOSE BULKHEAD CONNECTOR
LOOSE OR FAULTY REAR WIRING HARNESS OR TERMINALS
OPEN CIRCUIT TO FLASHER UNIT
OPEN CIRCUIT IN FEED WIRE TO TURN SIGNAL SWITCH
FAULTY SWITCH CONNECTIONS
FAULTY CONNECTION IN SWITCH
OPEN OR GROUNDED CIRCUIT IN WIRING TO EXTERNAL LAMPS
SYSTEM DOES NOT CANCEL AFTER COMPLETION OF TURN
BROKEN CANCELLING FINGER ON SWITCH
IMPROPER ALIGNED CANCELLING CAM
BROKEN OR LOOSE CANCELLING CAM
EXTERNAL LAMPS OPERATE PROPERLY, NO INDICATOR LAMP OPERATION
FAULTY INDICATOR BULB IN INSTRUMENT CLUSTER

Courtesy of Chrysler Motors

G. Illuminated entry trouble shooting chart


INTERIOR LAMPS INOPERABLE WHEN FRONT DOOR HANDLE IS LIFTED
LIFT OTHER FRONT DOOR HANDLE
IF LAMPS OPERATE CHECK WIRING CONNECTIONS AND SWITCH OF OTHER DOOR
IF LAMPS OPERATE OPEN DOOR
IF LAMPS OPERATE CHECK RELAY AND ITS CONNECTIONS
IF LAMPS OPERATE CHECK WIRING TO INTERIOR LAMPS
INTERIOR LAMPS STAY ON LONGER THAN 30±6 SECONDS ONCE DOOR HANDLE IS LIFTED
REPLACE RELAY
KEY CYLINDER LAMP INOPERABLE WHEN FRONT DOOR HANDLE IS LIFTED
INTERIOR LAMPS INOPERATIVE SEE ABOVE DIAGNOSIS
INTERIOR LAMPS OPERABLE CHECK LIGHT COLLECTOR WIRING, LIGHTPIPE INTO KEY CYLINDER AND COLLECTOR AND COLLECTOR LIGHT BULB
LAMPS REMAIN ON AFTER IGNITION SWITCH IS TURNED TO THE RUN POSITION
CHECK IGNITION FEED TO RELAY
IF FEED CIRCUIT IS SHORTED REPAIR CIRCUIT
IF FEED CIRCUIT IS OK REPLACE RELAY

Courtesy of Chrysler Motors

MODULE: ELECTRICAL SYSTEMS

PROCEDURE FOR DIAGNOSING AND TESTING AUTOMOTIVE LIGHT CIRCUITS

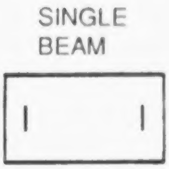
Instructions: **Do the following tasks on a separate sheet of paper.**

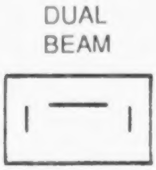
(HINT: Use an appropriate service manual.)

1. Develop a written procedure for dropping the light switch out of the dash of the vehicle to be serviced.

2. After determining the circuit served by each of the wires on the light switch, make a drawing of the switch, which shows the wiring. Indicate the circuit served by each wire. Also indicate when each wire receives voltage.

3. Identify high beam, low beam, and ground terminal on the back of a headlight and indicate what color of wire serves each terminal.





JS1-L2-UX

MODULE: ELECTRICAL SYSTEMS

DIAGNOSING AND TESTING AUTOMOTIVE LIGHT CIRCUITS

Equipment:

Hand tools
Volt meter
Jumper wires
VAT
Serviceable vehicle
Safety glasses

Procedure: Evaluation 3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Following the procedure outlined below, test the operation of all lighting circuits on the vehicle. __ __ __ __

   a. Activate each of the vehicle's light circuits and observe whether or not they work correctly. Check all the bulbs listed on the chart below.

      Light Bulb Verification Chart

      ___ Right low beam
      ___ Left low beam
      ___ Right tail light
      ___ Right brake light
      ___ Right rear side marker
      ___ Right backup light
      ___ License light
      ___ Right front side marker
      ___ Right front parking light
      ___ Right front turn signal
      ___ Right rear turn signal
      ___ Front emergency flasher

      ___ Right high beam
      ___ Left high beam
      ___ Left tail light
      ___ Left brake light
      ___ Left rear side marker
      ___ Left backup light
      ___ Trunk light
      ___ Left front side marker
      ___ Left front parking light
      ___ Left front turn signal
      ___ Left rear turn signal
      ___ Rear emergency flasher

___ Right turn dash light

___ Water temp warning light

___ Oil PSI warning light

___ Charging system warning light

___ Seat belt warning light

___ Door ajar warning light

___ Left turn dash light

___ Glove box light

___ Dash lights

___ Radio light

___ Dome light(s)

3. Following the procedure outlined below, service any light(s) that are not working properly. __ __ __ __

   a. Remove the bulb.

   b. Clean the light socket.

   c. Coat the bulb base, wires, and socket with moisture-repellant grease as needed.

   d. Install the bulb.

   e. Seal the fixture as needed.

   f. Make sure the light works correctly.

   g. Recommend steps to repair any bulb that does not work correctly.

4. Following the procedure outlined below, diagnose problems that cause a bulb to be too dim or too bright. Also diagnose problems that cause a bulb to glow intermittently. __ __ __ __

   a. Identify any bulbs that are too bright.

b. Recommend steps to correct any bulbs that are too bright.

c. Identify any bulbs that work intermittently.

d. Recommend steps to correct any bulb that works intermittently.

e. Identify any bulbs that are too dim.

f. Recommend steps to correct any bulb that is too dim. (Recommend steps other than performing a voltage drop test on the bulb's circuit.)

5. Using a series of voltage drop tests, diagnose problems causing a bulb to fail to light or to glow dimly. Follow the procedure outlined below. __ __ __ __

a. Complete AS1-L2-UX.

b. Drop the light switch down (out of) the dash so the wiring is accessible, but DO NOT UNPLUG the switch.

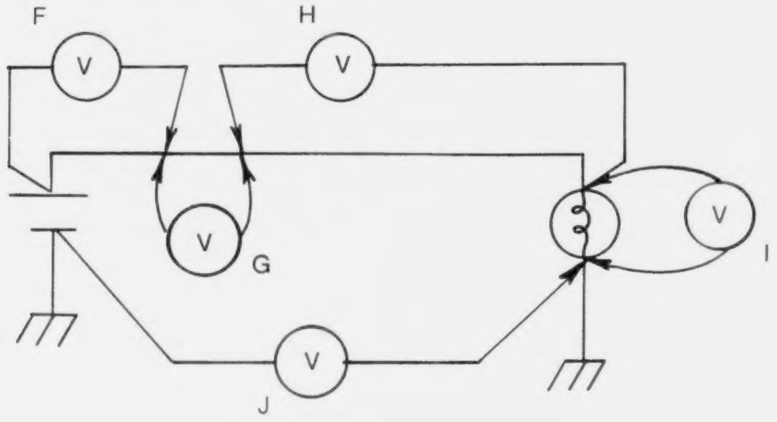
c. Perform the battery state-of-charge test. For the proper procedure, refer to JS3-L2-UIV. According to the state-of-charge test, the battery is:

OK ___ NOT OK ____

(NOTE: If the battery is not OK, recharge or replace it before continuing.)

d. Measure dynamic battery voltage with lights on high beam. Record results.

e. For each light circuit with a dimmer-than-normal bulb, perform the procedures in steps f through i below. Use the below illustration to help with the hookups.



Expected Result:

Positive circuit maximum Vd (f)	0.5 volts
Switch maximum Vd (g)	0.5 volts
Power wire to light (h)	0.5 volts
Load lights maximum Vd (i)	10-13 volts
Ground circuit (Vd) (j)	0.2 volts

(NOTE: Remember that dynamic battery voltage should equal the total of all voltage drops.)

(NOTE: Remember that voltage drops for any cluster of lights on one circuit are equal to the largest voltage drop of any single light on the circuit.)

f. Following the procedure outlined below, test the positive circuits (Vd).

1) Set the voltmeter to the 3-volt scale.

2) Connect red (Pos) lead to battery post.

3) Connect black (Neg) lead to the input terminal of the switch.

4) Turn on circuit.

5) Record results.

OK ____ NOT OK _____

6) If circuit is NOT OK, recommend steps to correct the problem.

g. Following the procedure outlined below, test the light switch (Vd).

1) Set the voltmeter to the 3-volt scale.

2) Connect red (Pos) lead to the input (supply) wire connected to the switch.

3) Connect black (Neg) lead to output terminal of the appropriate circuit being tested.

4) Turn on circuit.

5) Record results.

OK ____ NOT OK _____

6) If switch is NOT OK, recommend steps to correct the problem.

h. Following the procedure outlined below, test the wire that supplies current to the light.

1) Set the voltmeter to the 3-volt scale.

2) Connect red (Pos) lead to input (supply) wire going to switch.

3) Connect black (Neg) lead to the input (hot) wire going to the appropriate terminal at the light.

4) Turn on circuit.

5) Record results.

OK ____ NOT OK _____

6) If wire is NOT OK, recommend steps to correct the problem.

i. Following the procedure outlined below, test the load (lights) (Vd).

1) Set the voltmeter to the 12-volt scale.

2) Connect red (Pos) lead to input (supply) side of the light.

3) Connect black (Neg) lead to the grounded terminal of the appropriate light at the light.

4) Turn on circuit.

5) Record results.

OK ____ NOT OK _____

6) If the load is NOT OK, recommend steps to correct the problem.

j. Following the procedure outlined below, test the ground circuit (Vd).

1) Set the voltmeter to the 3-volt scale.

2) Connect red (Pos) lead to the grounded terminal of the light being tested.

3) Connect black (Neg) lead to the battery's negative terminal.

4) Turn on circuit.

5) Record results.

OK ____ NOT OK _____

6) If ground circuit is NOT OK, recommend steps to correct the problem.

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency H1. Final evaluation for H1 will be made at the end of JS2-L1-UX.)

MODULE: ELECTRICAL SYSTEMS

SERVICING HEADLIGHTS

Equipment:

Hand tools
Headlight aimer
Serviceable vehicle
Safety glasses

Procedure:

		Evaluation			
		3	2	1	N
1.	Wear safety glasses while doing all procedures on this job sheet.	__	__	__	__
2.	Service all nonfunctioning headlights.	__	__	__	__
3.	Using the procedure supplied by the manufacturer of the headlight aimer, access the adjuster screw and aim the headlights.	__	__	__	__
	Average of above evaluations*	__	__	__	__

(*This average is a partial evaluation for Competency H1. Final evaluation for H1 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency H1 by averaging the final evaluation of JS1-L2-UX and JS2-L2-UX. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS1-L2-UX	__	__	__	__
JS2-L2-UX	__	__	__	__
Final evaluation for Competency H1	__	__	__	__

MODULE: ELECTRICAL SYSTEMS

UNIT X: IDENTIFYING, DIAGNOSING, AND TESTING AUTOMOTIVE LIGHTING SYSTEMS

UNIT X TEST

PART I. LIGHTING SYSTEMS--GENERAL INFORMATION

SECTION A. Match the terms below with their appropriate definitions.

____ 1. The central core of an incandescent bulb.

____ 2. An electronic or liquid crystal device that self-illuminates to provide a warning or other information.

____ 3. A headlight that can be retracted flush to the hood surface.

____ 4. Any light that uses a glowing filament.

____ 5. An electrical device that opens or closes the concealed headlight assembly.

____ 6. A plastic or glass filament that transports light without additional wiring.

a. Actuator motor

b. Concealed headlight

c. Digital indicator

d. Fiber optic

e. Filament

ab. Incandescent lamp

ac. Control device

SECTION B. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 7. A sealed-beam bulb consists of a filament housed in a sealed, mercury-filled chamber.

____ 8. Double-filament headlights are used as high and low-beam lights in both two and four-headlight systems.

____ 9. In three-filament headlights, the third filament functions as a kind of fuse in order to protect the other two filaments.

____ 10. A halogen headlight uses a brightly burning carbon filament contained in a halogen-filled bulb.

____ 11. In some headlight systems, a relay is used to operate the headlight circuit.

____ 12. In a four-headlight system, an additional single-filament bulb is connected in parallel to the high-beam circuit.

____ 13. When used as tail or park lights, single filament bulbs do not perform a dual function.

____ 14. Side-marker lights are usually connected across the headlight circuits.

____ 15. A rheostat in the headlight switch is used to control digital meters in the dashboard.

____ 16. Fiber optics transport electrical current to digital meters.

____ 17. Dash lights can be hard wired, or they can work through a printed circuit.

____ 18. The primary function of courtesy lights is to make a vehicle more visible.

____ 19. Some courtesy light systems use a grounding switch circuit.

____ 20. In a contact switch circuit, the switch prevents current from flowing through the bulb and onto ground.

____ 21. A mercury switch circuit is a vial containing a mixture of mercury, magnesium and sulfate.

____ 22. The drive mechanism for the headlight door (in a concealed headlight system) is an electric motor, which is controlled by a relay and switch.

____ 23. The brake switch is normally closed or contacted; the switch opens, however, when pressure is applied to the break pedal.

____ 24. The hazard warning circuit is normally activated by the turn signal switch.

____ 25. When a vehicle is put into reverse, the backup light switch is activated by transmission linkage movement or by transmission fluid pressure.

(NOTE: The student must obtain a minimum score of ______ on Part I of the Unit X Test in order to receive an evaluation for Competencies H1 and H2.)

PART II. DIAGNOSING LIGHTING SYSTEM PROBLEMS AND DETERMINING NEEDED REPAIRS

SECTION A. Select the best answer from the five choices listed.

____ 26. The three categories of lighting system components are load device, control device, and

a. load-control device.
b. insulation device.
c. fiber optic device.
d. fiber optic control device.
e. none of the above.

____ 27. According to the Unit X information sheets, the two pieces of equipment most commonly used to test a lighting system load device are

a. a voltmeter and an ohmmeter.
b. a test light and an ohmmeter.
c. jumper leads and an ohmmeter.
d. an ammeter and an ohmmeter.
e. none of the above.

____ 28. The primary function of a lighting system control device is to

a. step down voltage in a circuit.
b. step up voltage in a circuit.
c. block powerful current surges.
d. dissipate strong magnetic fields.
e. switch current on and off.

____ 29. According to the Unit X information sheets, the two pieces of equipment most commonly used to test a lighting system control device are

a. an ohmmeter or a voltmeter.
b. a test light or a voltmeter.
c. an ammeter or a voltmeter.
d. an ammeter or an ohmmeter.
e. a test light or an ohmmeter.

____ 30. A lighting system control device can be tested

a. in circuit only.
b. out of circuit only.
c. either in circuit or out of circuit.
d. in circuit only if the vehicle uses digital read out gauges.
e. out of circuit only if the vehicle uses digital read out gauges.

____ 31. One example of a load-control device is

a. a battery.
b. a hydrometer.
c. a digital read out gauge.
d. an electromechanical relay.
e. a halogen headlight.

____ 32. When activating a relay from a remote source with the circuit on, the coil terminal can be grounded with a

a. fiber optic.
b. piece of plastic insulation.
c. voltage regulator.
d. small piece of tungsten steel.
e. jumper lead.

SECTION B. **Read each of the below statements made by technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.**

____ 33. Technician I says that, if headlights dim when engine is idling, the charging system should be tested.

Technician II says that, if headlights dim when engine is idling, there are probably loose connections within the headlight circuit.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 34. Technician I says that, if a vehicle's sealed bulbs frequently burn out, the headlight circuit may have loose connections.

Technician II says that, if a vehicle's sealed bulbs frequently burn out, the charging system should be checked.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 35. Technician I says that, if a vehicle's headlights dim when the engine is running above idle, the beams or bulbs may have faulty seals.

Technician II says that, if a vehicle's headlights dim when engine is running above idle, there may be an open or corroded contact in the dimmer switch.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 36. Technician I says that, if a vehicle's headlights flash randomly, the headlight circuit may be poorly grounded.

Technician II says that, if a vehicle's headlights flash randomly, a headlight torsion bar may be broken or disengaged.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 37. Technician I says that, if a vehicle's headlights will not come on, the alternator should be tested.

Technician II says that, if a vehicle's headlights will not come on, the voltage regulator should be tested.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 38. Technician I says that, if concealed headlight doors will not function, there could be a burned out fuse, circuit breaker, or fusible link within the concealed headlight system.

Technician II says that subfreezing temperatures can cause headlight doors to fail to open.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 39. Technician I says that, if the turn signal system fails to flash on one side, the system may have a faulty contact switch.

Technician II says that, if the turn signal fails to flash on one side the system may have a faulty fuse.

Who is right? (a) I only(b) (b) II only
(c) both I and II (d) neither I nor II

____ 40. Technician I says that, if the turn signal system does not cancel after completion of the turn, one of the bulbs may have a burned-out filament.

Technician II says that, if the turn signal system does not cancel after the completion of the turn, the system may be poorly grounded at the lamp.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of _____ on Part II of the Unit X Test in order to receive an evaluation for Competency H1.)

ANSWERS TO UNIT X TEST

1. e
2. c
3. b
4. ab
5. a
6. d
7. f
8. f
9. f
10. f
11. t
12. t
13. t
14. f
15. f
16. f
17. t
18. f
19. t
20. t
21. f
22. t
23. f
24. f
25. t
26. b
27. c
28. e
29. b
30. c
31. d
32. e
33. a
34. b
35. b
36. a
37. d
38. c
39. a
40. d

MODULE: ELECTRICAL SYSTEMS

UNIT XI: REPAIRING AND REPLACING AUTOMOTIVE LIGHTING SYSTEM COMPONENTS

UNIT OBJECTIVE

After completing this unit, the student should be able to repair and replace vehicle lights, sockets, wires, and switches. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1. I. Identify procedures for repairing and replacing automotive headlights (Competency H2, Unit XI Test).

II. Identify procedures for removing and replacing taillights, stop lights, and turn signals (Competency H2, Unit XI Test).

III. Demonstrate the ability to:

- a. Repair and replace lighting system components (Competency H2, JS1-L1-UXI).

ASE TASKS COVERED IN THIS UNIT

I. The job sheet in this unit can be adapted to cover ASE tasks F046, F048, F050, F052, F054, F056, F057, F059, F060 F062, and F063.

MODULE: ELECTRICAL SYSTEMS

UNIT XI: REPAIRING AND REPLACING AUTOMOTIVE LIGHTING SYSTEM COMPONENTS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

   1. Lesson 1: REPAIRING AND REPLACING AUTOMOTIVE LIGHTS, SOCKETS, WIRES, AND SWITCHES

      a. Information outline

      b. Assignment sheets

         AS1-L1-UXI: Procedure for Checking, Repairing, and Replacing Automotive Light Circuit Components

      c. Job sheets

         JS1-L1-UXI: Repairing and Replacing Lighting System Components

E Unit test

F Answers to unit test

REFERENCES

Battery Council International. Battery Service Manual. Chicago: Battery Council International, 1982.

Chrysler Motors. 1988 Service Manual: Electrical, Fuel, and Emission Systems: Front Wheel Drive Car.

Chrysler Motors. 1988 Service Manual: Engine, Chassis, and Body: Front Wheel Drive Car.

Chrysler Motors. 1988 Service Manual: Wiring Diagrams: Front Wheel Drive Car.

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DeKryger, William, J., Robert T Kovacik, and Saverio G. Bono. Auto Mechanics Theory and Service. Cincinnati: South-Western Publishing Company, 1986.

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Downing, Ronald. Automotive Electrical Systems and Tune-up Procedures: Instructor's Guide. Module 5 of Auto Mechanics. University of Missouri-Columbia: Instructional Materials Laboratory, 1981.

Mitchell Information Services, Inc. 1986 Domestic Cars Tune up Mechanical Service and Repair. San Diego: Mitchell Information Services, Inc., 1986.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Students should do AS1-L1-UXI in conjunction with JS1-L1-UXI.

MODULE: ELECTRICAL SYSTEMS

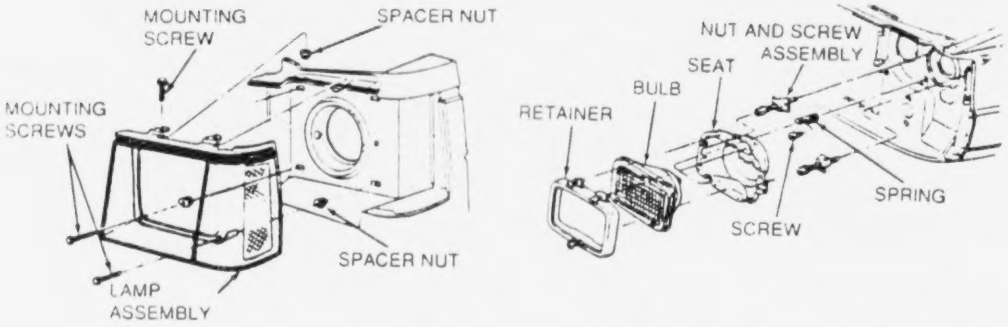
UNIT XI: REPAIRING AND REPLACING AUTOMOTIVE LIGHTING SYSTEM COMPONENTS

LESSON 1: REPAIRING AND REPLACING AUTOMOTIVE LIGHTS, SOCKETS, WIRES, AND SWITCHES

I. Procedure for repairing and replacing automotive headlights

   A. Procedure for replacing sealed-beam headlights

      1. Remove decorative trim.
      2. Remove headlight retaining ring.
      3. Pull the headlight away from its mount.
      4. Remove the connector from the back of the headlight.
      5. Replace the old headlight with a new one.
      6. Align the locating tabs of the new headlight with the mount.
      7. Make sure the new headlight operates properly.
      8. To replace the headlight, reverse the procedure.

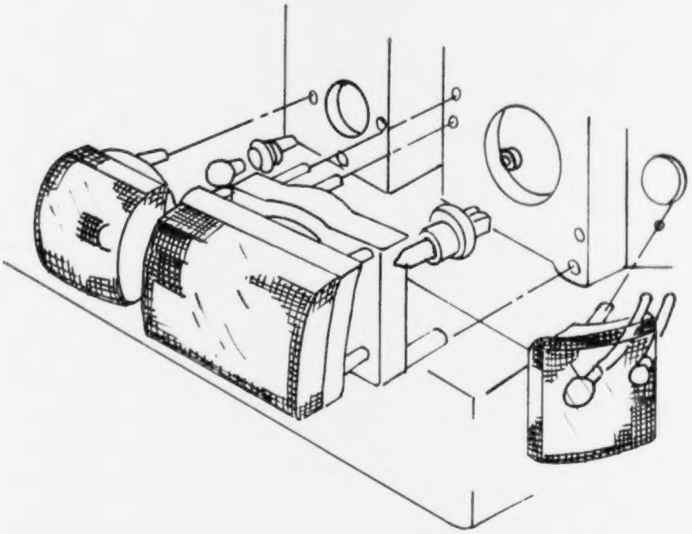

MOUNTING SCREW
SPACER NUT
MOUNTING SCREWS
LAMP ASSEMBLY
SPACER NUT
NUT AND SCREW ASSEMBLY
SEAT
BULB
RETAINER
SPRING
SCREW

Courtesy of Chrysler Motors

   B. Procedure for replacing halogen aerodynamic headlights

      1. Remove the electrical connector from the rear of the lamp assembly.
      2. Grasp the plastic bulb retainer. Gently twist and pull the retainer until the bulb is free of the assembly.
      3. To replace the bulb, reverse the procedure.

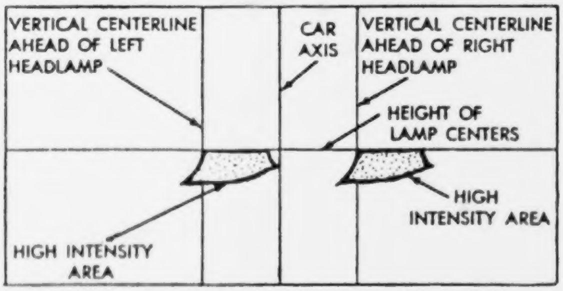
(**CAUTION**: Do not handle the glass surface of the new bulb. Oil from hands can remain on the bulb, causing it to swell and burst during periods of intense heat.)

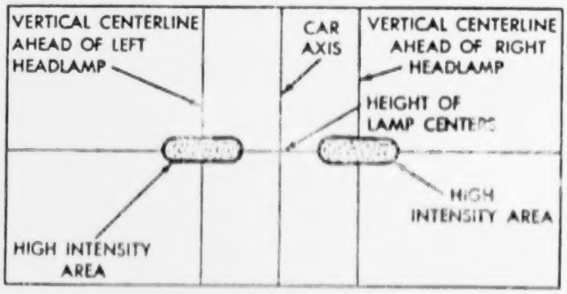


C. Procedure for aiming the headlights using an aiming screen

1. Align vehicle headlights with a mark located at a specific distance from the vertical screen (usually 20 to 25 feet).

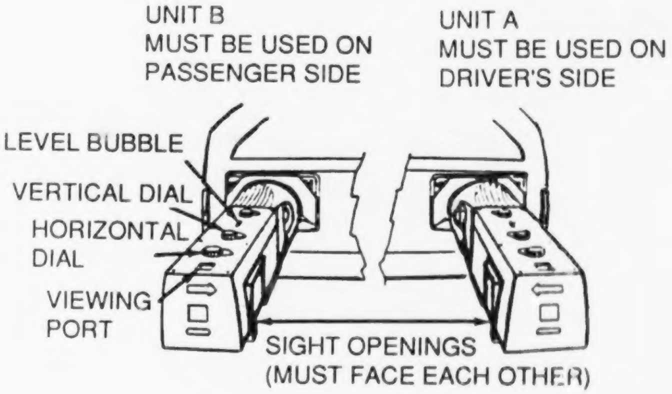
2. Adjust the vertical and horizontal screws on the edge of the mount so that the headlights align with the mark on the screen.


VERTICAL CENTERLINE AHEAD OF LEFT HEADLAMP
CAR AXIS
VERTICAL CENTERLINE AHEAD OF RIGHT HEADLAMP
HEIGHT OF LAMP CENTERS
HIGH INTENSITY AREA
HIGH INTENSITY AREA


VERTICAL CENTERLINE AHEAD OF LEFT HEADLAMP
CAR AXIS
VERTICAL CENTERLINE AHEAD OF RIGHT HEADLAMP
HEIGHT OF LAMP CENTERS
HIGH INTENSITY AREA
HIGH INTENSITY AREA

Courtesy of Chrysler Motors

D. A device called a headlight aimer is often used to aim headlights. There are many types of headlight aimers. Some aimers measure the position of the lamp centers; others determine the geometric position of the lamp faces in relation to each other and to gravity. Specific models of headlight aimers will have their own unique instructions.


UNIT B
MUST BE USED ON
PASSENGER SIDE
UNIT A
MUST BE USED ON
DRIVER'S SIDE
LEVEL BUBBLE
VERTICAL DIAL
HORIZONTAL
DIAL
VIEWING
PORT
SIGHT OPENINGS
(MUST FACE EACH OTHER)

Courtesy of Chrysler Motors

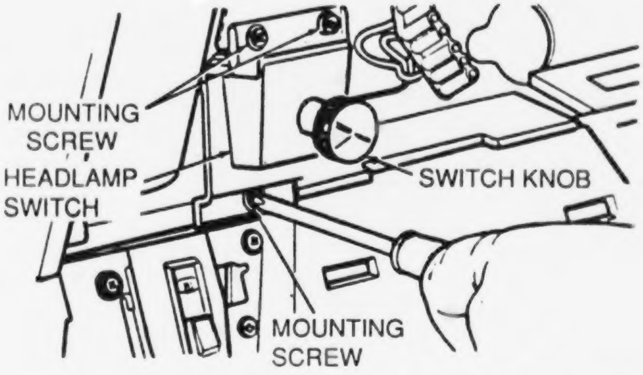
E. Vehicle headlights can be controlled either by a relay mechanism or a switch. Each vehicle model requires a somewhat different procedure for replacing either of these control devices.

F. The relay-controlled headlight switch is a light-duty switch that activates a heavy current relay. The switch is usually small and can be located anywhere within the driver's reach. (The illustration below depicts only one type of relay-controlled switch.) The replacement procedure is determined by the location of the switch. Consult the vehicle service manual for the correct replacement procedure.

G. The headlight switch is a heavy-duty, current-carrying, push-pull switch. It is somewhat bulky and, therefore, can be located in only a limited number of positions (usually on the left side of the dash).

(NOTE: Outlined below is the basic procedure for replacing the headlight switch. Details of the procedure may vary, depending upon the model of vehicle.)

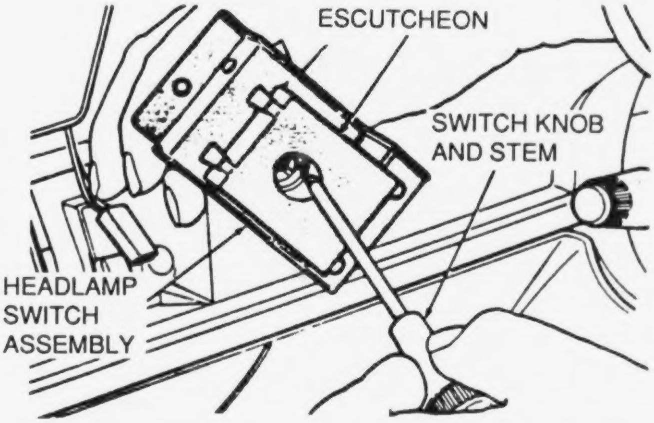
1. Disconnect battery negative cable.


MOUNTING
SCREW
HEADLAMP
SWITCH
SWITCH KNOB
MOUNTING
SCREW

Courtesy of Chrysler Motors

2. Remove switch retaining screw.

3. Reach behind switch and locate the spring lock tab.


ESCUTCHEON
SWITCH KNOB
AND STEM
HEADLAMP
SWITCH
ASSEMBLY

Courtesy of Chrysler Motors

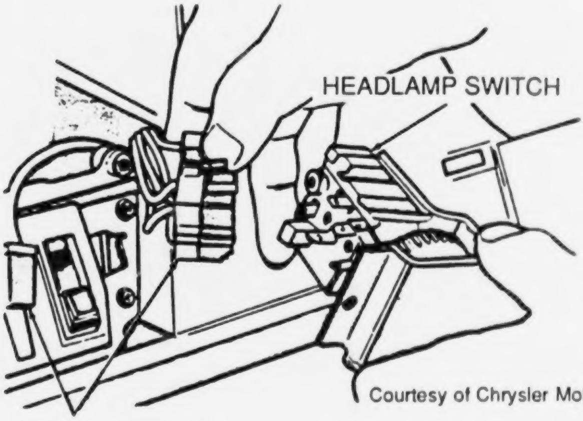
4. Pull switch completely out.

5. Depress lock tab and pull knob from the switch.

6. Remove trim bezel from the switch.

7. Pull the switch from the dash.

8. Remove the switch's wiring connector.



Courtesy of Chrysler Motors

9. To replace switch, reverse disassembly procedure.

II. Removing and replacing taillights, stop lights, and turn signals

A. Procedure for removing taillight and stop light bulbs

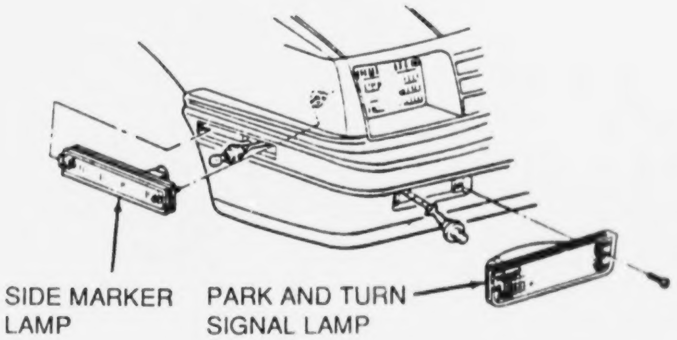
(NOTE: Outlined below is the basic procedure for removing taillight and stop light bulbs. Details of the procedure may vary, depending upon the model of vehicle.)

1. Twist lamp socket until locking tabs enter the slots.

2. Pull back on the socket till it clears the lamp housing.

3. Grasp bulb and push it in slightly; then, twist the bulb about one-eighth of a turn and pull it out.

4. When replacing the bulb, be sure to align the correct indexing pin to the correct groove on the socket.

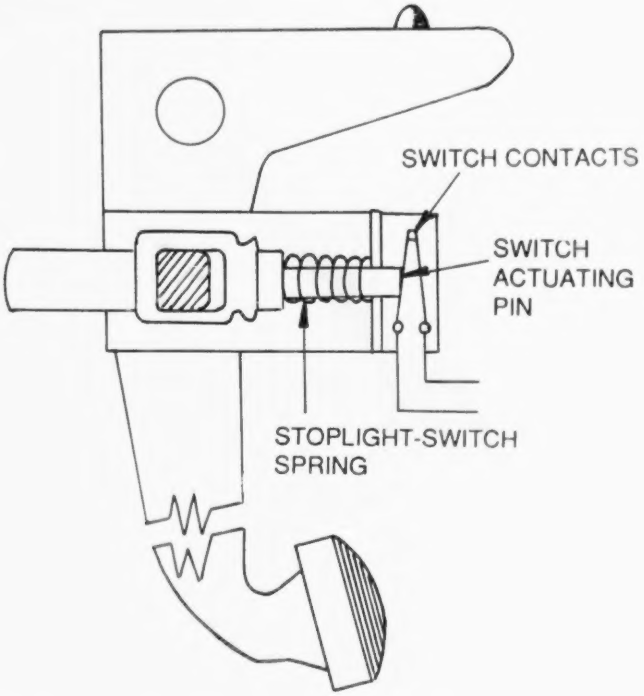


Courtesy of Chrysler Motors

B. The brake switch is mounted on or near the brake lever. Pressing the pedal will close the contacts, causing the brake circuit to be energized.

(NOTE: Outlined below is the basic procedure for brake switch removal. Details of the procedure may vary depending upon the model of vehicle.)

1. Disconnect battery negative cable.
2. Locate brake switch.
3. Release locking tab on the switch and remove it.
4. Replace switch and adjust for proper length.



C. Procedure for replacing the turn signal switch

(NOTE: Outlined below is a basic procedure for removing the turn signal switch. This procedure requires partial disassembly of the steering column, which is a very complex device. Always consult a service manual before attempting to service any part of the column.)

1. Remove the horn button.
2. Remove the horn ring.
3. Remove the steering wheel nut.
4. Put an index mark on the shaft and steering wheel hub.

5. Using a suitable puller, pull the steering wheel.

6. Remove the turn signal lever.

7. Remove the hazard button.

8. Remove retaining screws.

9. Disconnect multiple connector at the base of the column.

10. Remove harness cover.

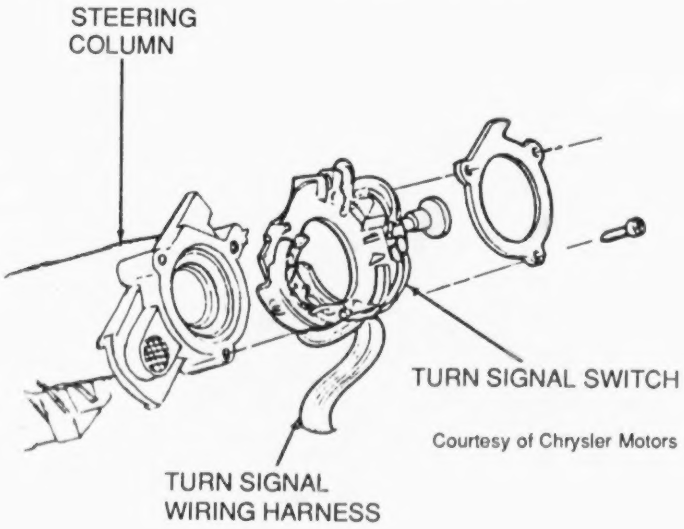
11. Attach a length of mechanics wire to the multiple connector.

12. Slide switch up and out of the column while feeding the connector and wire from the bottom.

13. When the connector clears the top of the column, disconnect the mechanics wire and leave it in the column for use during the replacement procedure.

14. Attach new switch connector to the mechanics wire and feed it into the column.

15. To replace the turn signal switch, reverse the procedure.



Courtesy of Chrysler Motors

D. In the automobile, small lamps are used as dash lights, side markers, and courtesy lights. There are two basic types of small lamps: wedge and miniature bayonet.

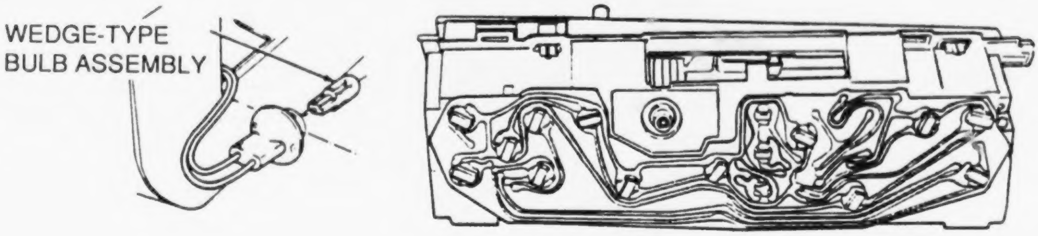
1. Wedge lamps are gripped by metal fingers in the socket. The lamps can be replaced by following the procedure outlined below.

    a. Remove the socket from the lamp housing.

    b. Pull outward on the bulb.

c. Aligning the wedge with the slot, insert the new bulb.

d. To replace the bulb, reverse the procedure.



Courtesy of Chrysler Motors

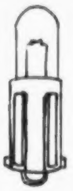
2. Miniature bayonets look very much like taillight and stop light bulbs; the bayonets are smaller, however. Care must be taken to align the indexing pins on the bulb with the slots in the socket.

    a. Remove the socket from the lamp housing.

    b. Push in slightly on the bulb and twist.

    c. Pull the bulb out.

    d. To replace the bulb, reverse the procedure.



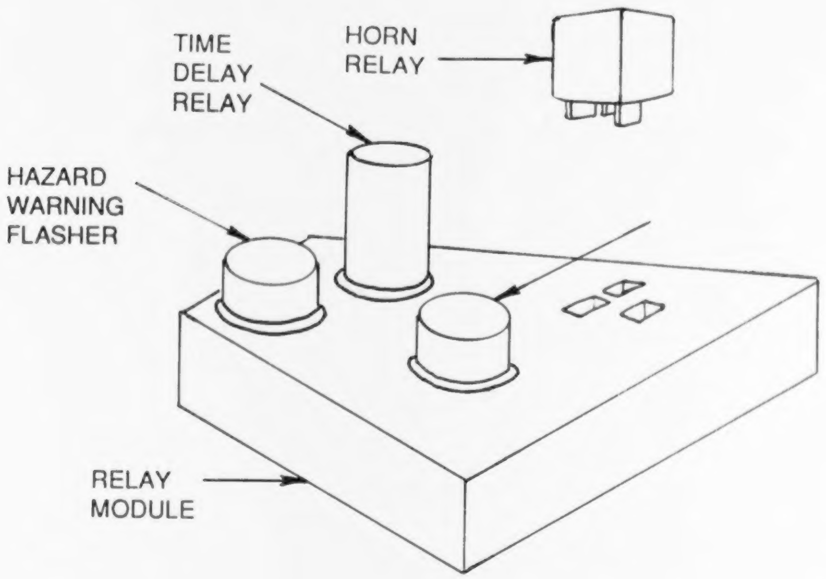
E. Relays, flashers, backup light switches, and concealed headlight motors

1. Procedure for replacing relays and flashers

    a. Using the service manual, locate the position of the relay or flasher.

    b. Remove the relay or flasher from the mount.

    c. Disconnect the relay or flasher from the wiring harness in the panel.


TIME
DELAY
RELAY
HORN
RELAY
HAZARD
WARNING
FLASHER
RELAY
MODULE

2. Procedure for replacing back up light switch

   (NOTE: Outlined below is the basic procedure for replacing a back up light switch. Details of the procedure may vary, depending upon the model of vehicle.)

   a. Remove wiring connector.

   b. Place drain pan under the vehicle.

   c. Unscrew switch.

   d. Replace with new seal.

   e. Reverse disassembly.

MODULE: ELECTRICAL SYSTEMS

PROCEDURE FOR CHECKING, REPAIRING, AND REPLACING AUTOMOTIVE LIGHT SYSTEM COMPONENTS

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for testing components in circuits containing nonfunctioning lights in the vehicle to be serviced. Clearly identify the circuit to be serviced. Also include the circuit's wiring and connectors in the procedure.
3. Develop a written procedure for repairing or replacing any components found to be defective as a result of performing the test procedure developed in item 2 of this assignment sheet. Clearly identify the components to be serviced.

JS1-L1-UXI

MODULE: ELECTRICAL SYSTEMS

REPAIRING AND REPLACING LIGHTING SYSTEM COMPONENTS

Equipment:

Hand tools
Voltmeter
Ohmmeter
Test light
Jumper cables
Serviceable vehicle
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Identify any malfunctioning lighting circuits on the vehicle to be serviced. Make sure all bulbs and fuses within these circuits are OK. List any defective circuits below. __ __ __ __

3. Following the procedure outlined below, check the operation of components within each of the vehicle's circuits containing nonfunctioning lights. __ __ __ __

    a. Complete items 1 and 2 of AS1-L1-UXI.

    b. Using the procedure developed in item 2 of AS1-L1-UXI, check the operation of the components in each of the vehicle's circuits connected to nonfunctioning lights. Record results.

    c. Recommend steps that can be taken to correct the problem.

4. Following the procedure outlined below, repair faulty vehicle circuits connected to nonfunctioning lights. Obtain permission from the instructor before making any repairs. _ _ _ _

    a. Complete item 3 of AS1-L1-UXI.

    b. Using the procedure developed in item 3 of AS1-L1-UXI, repair any circuit connected to nonfunctioning lights.

    c. Test repaired circuits to confirm that they are functioning properly. The circuits are:

    OK _____NOT OK ____

    d. If NOT OK, explain why the circuit is still not functioning properly.

Average of above evaluations* _ _ _ _

(*This is the final evaluation for Competency H2.)

MODULE: ELECTRICAL SYSTEMS

UNIT XI: REPAIRING AND REPLACING LIGHTING SYSTEM COMPONENTS

UNIT XI TEST

SECTION A. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 1. When replacing halogen headlights, the technician should never touch the glass surface of the new bulb with his or her bare hands.

____ 2. Both an aiming screen and a headlight aimer are required to aim headlights.

____ 3. When using an aiming screen, the technician should align vehicle headlights with a mark that is usually about 50 to 75 feet from the vertical screen.

____ 4. Some headlight aimers align the lamp centers with the rearview mirror, which is usually located exactly in the vehicle's center.

____ 5. Some headlight aimers determine the geometric position of the headlight faces in relation to each other and to gravity.

____ 6. Vehicle headlights can be controlled by either a relay mechanism or a switch.

____ 7. The relay-controlled headlight switch is a light-duty device, which activates a heavy current relay.

____ 8. The headlight switch is a heavy-duty, current-carrying device that can be easily located anywhere within the driver's reach.

____ 9. While procedures for replacing most lighting system components often vary, the procedure for replacing the headlight switch is usually the same.

____ 10. Upon application of the break pedal, the break switch contacts close, thus energizing the break circuit.

____ 11. There are three basic types of small lamps: square block, wedge, and miniature bayonet.

____ 12. Wedge lamps are gripped by metal fingers in the socket.

____ 13. Miniature bayonets look like very small taillight and stop light bulbs.

____ 14. Small lamps are used in courtesy lighting systems.

____ 15. Small lamps are used in dashboard lighting systems.

(NOTE: The student must obtain a minimum score of ______ on the Unit XI Test in order to receive an evaluation for Competency H2.)

ANSWERS TO UNIT XI TEST

1. t
2. t
3. f
4. f
5. t
6. t
7. t
8. f
9. f
10. t
11. f
12. t
13. t
14. t
15. t

MODULE: ELECTRICAL SYSTEMS

UNIT XII: AUTOMOTIVE GAUGES, WARNING DEVICES, AND DRIVER INFORMATION SYSTEMS

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose and repair gauge and warning circuits. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with gauges, warning devices, and driver information systems (Competency I1, Unit XII Test).

II. Identify gauge components and circuits (Competency I1, Unit XII Test).

III. Identify procedures for diagnosing, testing, and repairing, or replacing automotive gauge system components (Competency I1, Unit XII Test).

IV. Identify driver warning and driver information systems (Competency I1, Unit XII Test).

V. Identify procedures for diagnosing, testing, repairing, and replacing an automotive warning system (Competency I1, Unit XII Test).

VI. Demonstrate the ability to:

   a. Diagnose and repair gauge circuits (Competency I1, JS1-L1-UXII).

   b. Diagnose and repair indicator light circuits (Competency I1, JS2-L1-UXII).

   c. Diagnose and repair audible warning device circuits (Competency I1, JS3-L1-UXII).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit can be adapted to cover ASE tasks A060, and F064-F071.

MODULE: ELECTRICAL SYSTEMS

UNIT XII: AUTOMOTIVE GAUGES, WARNING DEVICES, AND DRIVER INFORMATION SYSTEMS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: DIAGNOSING AND REPAIRING AUTOMOTIVE GAUGES, WARNING DEVICES, AND DRIVER INFORMATION SYSTEMS

    a. Information outline

    b. Assignment sheets

      AS1-L1-UXII: Procedures for Diagnosing Gauge Circuits
      AS2-L1-UXII: Procedures for Diagnosing Indicator Light Circuits
      AS3-L1-UXII: Procedures for Diagnosing Audible Warning Device Circuits

    c. Job sheets

      JS1-L1-UXII: Diagnosing and Repairing Intermittent High and Low Gauge Reading or No Gauge Reading
      JS2-L1-UXII: Diagnosing and Repairing Intermittent or Constant Indicator Light or Indicator Light that Fails Completely
      JS3-L1-UXII: Diagnosing and Repairing Intermittent or Constant Operation of Audible Warning System Device or the Failure of an Audible Warning System Device

E. Unit test

F. Answers to unit test

REFERENCES

Battery Council International. Battery Service Manual. Chicago: Battery Council International, 1982.

Chrysler Motors. 1988 Service Manual: Electrical, Fuel, and Emission Systems: Front Wheel Drive Car.

Chrysler Motors. 1988 Service Manual: Engine, Chassis, and Body: Front Wheel Drive Car.

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Mitchell Information Services, Inc. 1986 Domestic Cars Tune up Mechanical Service and Repair. San Diego: Mitchell Information Services, Inc., 1986.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L1-UXII in conjunction with JS1-L1-UXII; AS2-L1-UXII in conjunction with JS2-L1-UXII; and AS3-L1-UXII in conjunction with JS3-L1-UXII.

MODULE: ELECTRICAL SYSTEMS

UNIT XII: AUTOMOTIVE GAUGES, WARNING DEVICES, AND DRIVER INFORMATION SYSTEMS

LESSON 1: DIAGNOSING AND REPAIRING AUTOMOTIVE GAUGES, WARNING DEVICES, AND DRIVER INFORMATION SYSTEMS

I. Terms and definitions

A. Audible warning device--A sound-producing device that alerts the driver to a problem in the vehicle. Audible warning devices include bells, buzzers, or even synthesized voices.

B. Bimetallic gauge--A gauge in which a small heater flexes a bimetal strip in order to vary needle movement. The movement of the needle indicates varying amounts of current going to a circuit.

C. Electronic gauge--A device that uses an electronic circuit to display a digital reading, illuminate a lamp, or activate an audible warning.

D. Fuel level gauge--Either a bimetallic or magnetic gauge that indicates a vehicle's fuel level.

E. Ignition key warning--An audible warning device which signals that the key has been left in the ignition switch after the engine has been turned off.

F. Illuminated warning--A lamp that comes on to warn the driver of a problem in the vehicle.

G. Instrument voltage regulator--A device that delivers regulated voltage (usually an average of five volts) to the gauge circuit.

H. Low fuel alarm--An audible or illuminated warning device that indicates when a vehicle's fuel is low.

I. Magnetic gauge--An indicator gauge that uses balancing coils and magnetic fields to move the indicator needle. Movement of the needle is based on the rate of current flow through the gauge.

J. Oil pressure indicator--Either a gauge that indicates the amount of engine oil pressure or a warning light that indicates the lack of engine oil pressure.

K. Seat belt warning--A time-delayed audible warning that reminds passengers to fasten their seat belts.

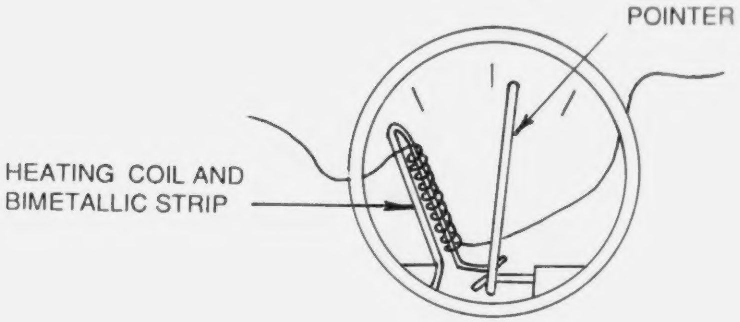
L. Sending unit--A pressure, temperature, or position-sensing device that controls current flow through an alarm, gauge, or driver information system.

M. Temperature indicator--A gauge or warning light that indicates dangerously high engine coolant temperatures.

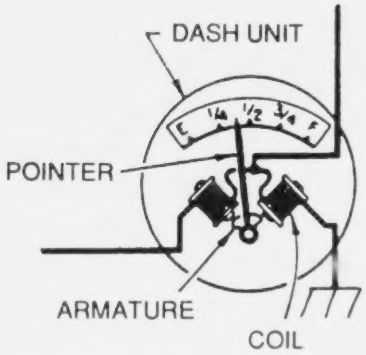
II. Identifying gauge components and circuits

A. Types of gauges and gauge controls

1. The bimetallic gauge consists of a bimetal strip wrapped in a heating coil. Current flowing through the coil heats the bimetal strip, causing it to bend. Varying the rate of current flow through the coil will, therefore, vary the movement of the strip. A linkage connects the strip to a moveable needle.

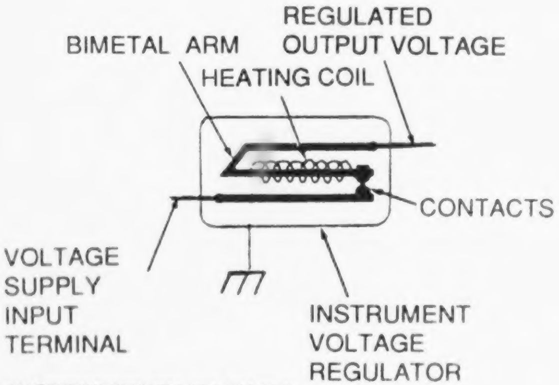


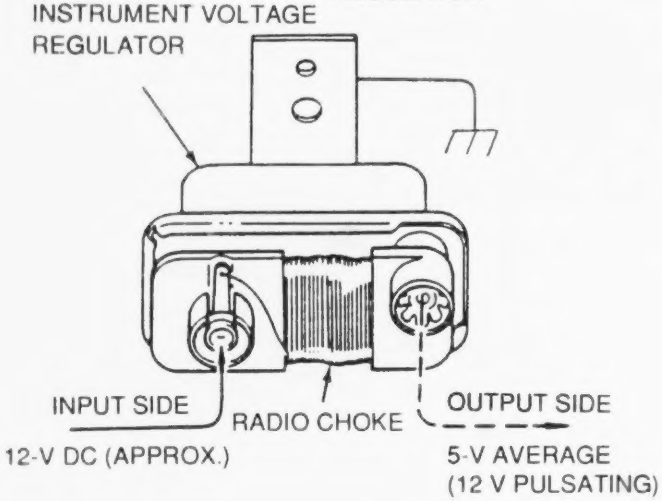
2. The magnetic gauge consists of two field coils placed around an armature. When the coils receive current, they produce a magnetic field, which moves the armature. Varying current flow through the coils will, therefore, vary the extent of armature movement.



Reproduced by permission.
Crouse, W.H. **AUTOMOTIVE ELECTRONICS AND ELECTRICAL EQUIPMENT**
10th ed. New York: McGraw-Hill Book Company, 1986.

3. The instrument voltage regulator (IVR) is a load-control device, which maintains an average of 5 volts of current flow to the gauge circuit. The IVR consists of a bimetal strip wrapped in a heater coil. When the IVR contacts are closed, the heater rapidly warms up and causes the bimetal strip to flex, once again breaking open the contacts. When current flow stops, the heater cools. The strip then returns to the closed position, again creating a current path through the gauge circuit. By coming off and on repeatedly, the IVR maintains even current flow through the circuit and thus counteracts the negative effects of fluctuating battery voltage.

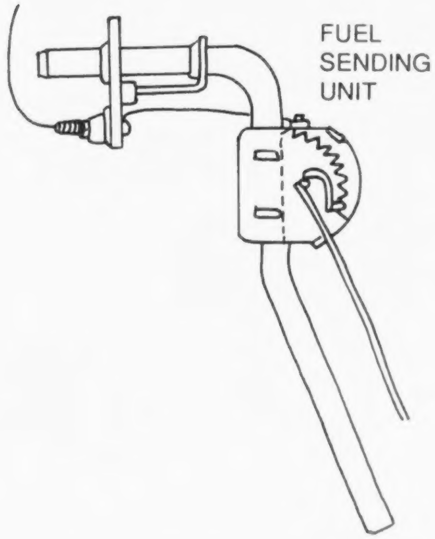

REGULATED OUTPUT VOLTAGE
BIMETAL ARM
HEATING COIL
CONTACTS
VOLTAGE SUPPLY INPUT TERMINAL
INSTRUMENT VOLTAGE REGULATOR


INSTRUMENT VOLTAGE REGULATOR
INPUT SIDE
12-V DC (APPROX.)
RADIO CHOKE
OUTPUT SIDE
5-V AVERAGE
(12 V PULSATING)

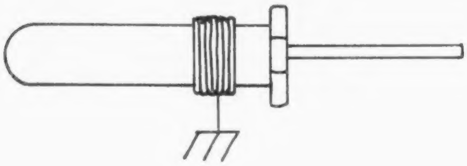
Courtesy of Ford Motor Company

4. Sending units (gauge control devices)

   a. A potentiometer is a sending unit in which resistance is varied by the action of a wrapped coil and a sliding contact. As the mechanical linkage moves the contact up and down the coil, the series resistance of the coil will vary.

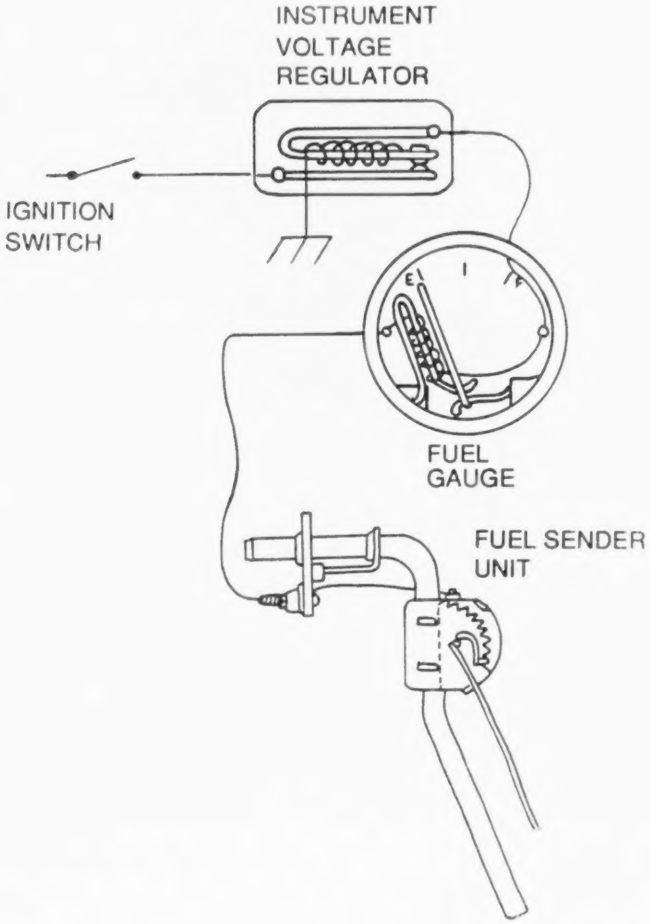


   b. A thermistor is a solid-state unit that varies its resistance in relation to temperature. As the temperature varies, the current flow through the thermistor will vary.

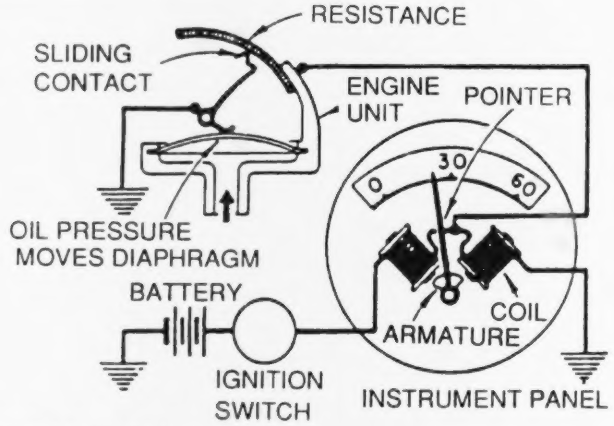


B. Typical gauge circuits

1. Fuel gauge system circuit


INSTRUMENT VOLTAGE REGULATOR
IGNITION SWITCH
E
F
FUEL GAUGE
FUEL SENDER UNIT

2. Oil pressure system circuit


RESISTANCE
SLIDING CONTACT
ENGINE UNIT
POINTER
0
30
60
OIL PRESSURE MOVES DIAPHRAGM
BATTERY
COIL
ARMATURE
IGNITION SWITCH
INSTRUMENT PANEL

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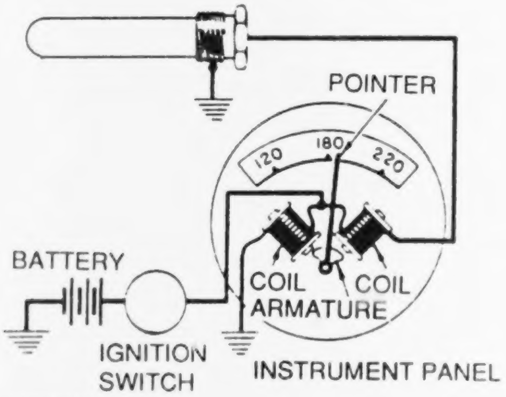
Crouse, W.H. **AUTOMOTIVE ELECTRONICS AND ELECTRICAL EQUIPMENT**.
10th ed. New York: McGraw-Hill Book Company, 1986.

3. Temperature gauge system circuit


POINTER
120
180
220
BATTERY
COIL
COIL
ARMATURE
IGNITION SWITCH
INSTRUMENT PANEL

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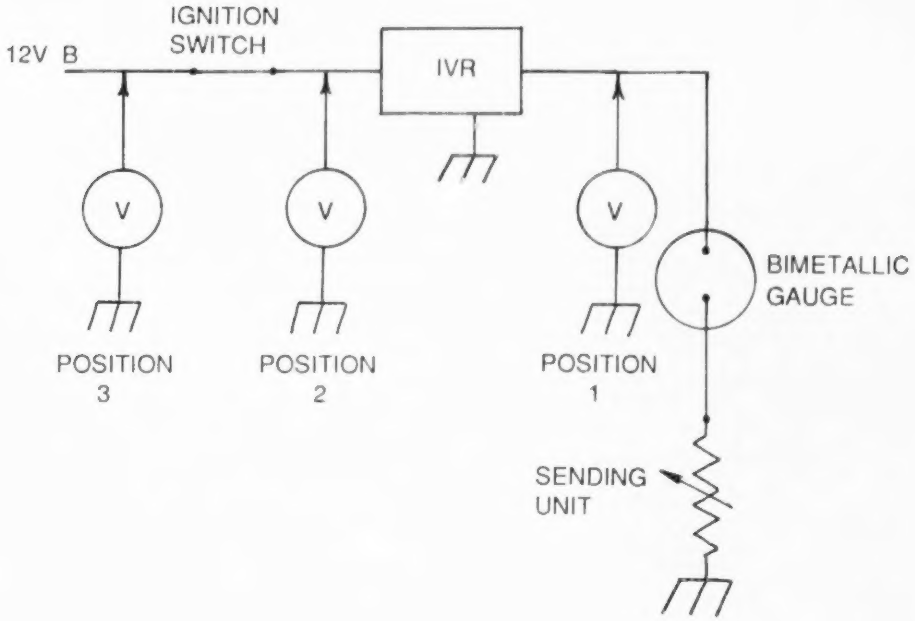
Crouse, W.H. **AUTOMOTIVE ELECTRONICS AND ELECTRICAL EQUIPMENT**.
10th ed. New York: McGraw-Hill Book Company, 1986.

III. Diagnosing, testing, repairing, or replacing gauge system components

A. Symptoms of gauge system malfunctions

1. Rapid needle vibration is usually caused by a sluggish instrument voltage regulator (IVR). No repair is possible; the unit must be replaced.

2. If all gauges fail to function, there could be a loss of continuity in the regulated supply circuit. To confirm this diagnosis, the technician should check the fuse, check the IVR, and examine the circuit for opens.


IGNITION SWITCH
12V B
IVR
V
V
V
BIMETALLIC GAUGE
POSITION 3
POSITION 2
POSITION 1
SENDING UNIT

3. If only one gauge fails to function, there could be a problem in the gauge or the sending unit. Follow the below procedure to determine the cause of a single-gauge malfunction.

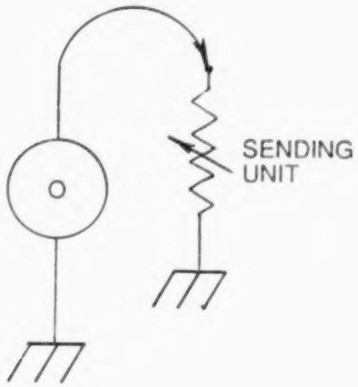
   a. Disconnect the sending unit.

   b. Connect a voltmeter in series to the wire and ground.

   c. The volt reading should fluctuate and thus cause the gauge to fluctuate.

   d. If the gauge gives no reading or does not fluctuate, there is an open in either the circuit, the gauge, or the IVR.

e. If the volt reading is fluctuating, select RX1 scale on the voltmeter and connect the voltmeter lead to the sending unit. If the meter reading is 0 or infinite, replace the sending unit.



B. Replacing gauge system components

1. The instrument voltage regulator (IVR) is mounted on the back of the instrument cluster. IVR replacement, therefore, usually requires the removal of the cluster. Outlined below is a procedure for replacing the IVR.

   (NOTE: Details of the procedure may vary depending upon the model of vehicle.)

   a. Disconnect negative battery cable.

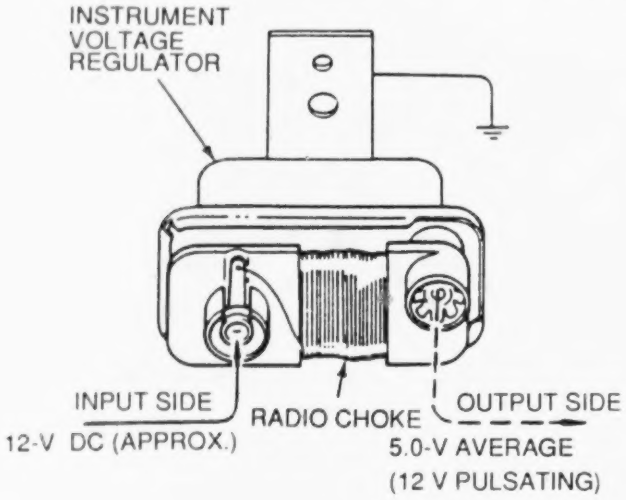
   b. Remove cluster bezel.

   c. Remove cluster mask or lens.

   d. Remove cluster assembly.

   e. Locate and disconnect the IVR.

f. Reverse procedure to replace IVR.

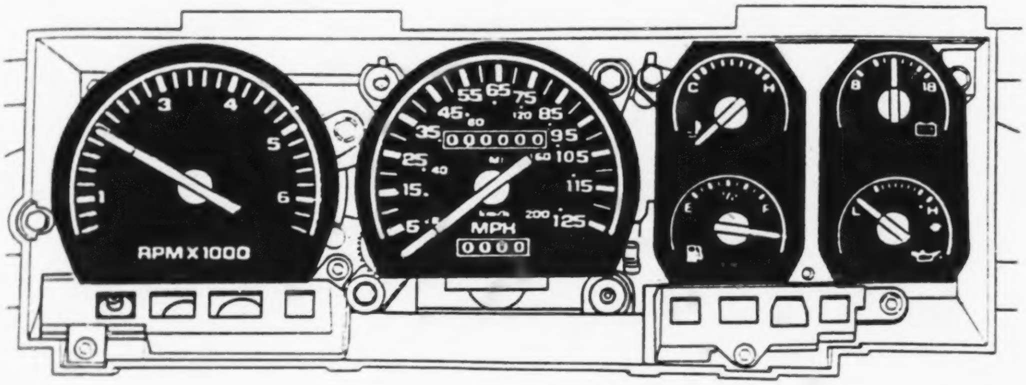

INSTRUMENT VOLTAGE REGULATOR
INPUT SIDE
12-V DC (APPROX.)
RADIO CHOKE
OUTPUT SIDE
5.0-V AVERAGE
(12 V PULSATING)

Courtesy of Ford Motor Company

2. Procedure for replacing gauge unit

   a. Disconnect the negative battery cable.

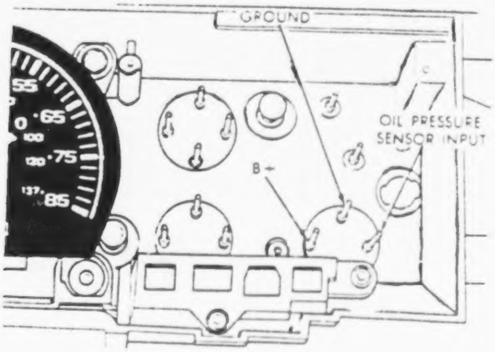
   b. Remove bezel.


RPM X 1000
MPH
C
H
E
F
L
H

Courtesy of Ford Motor Company

   c. Remove cluster lens.

d. Grasp gauge unit and carefully pull it straight out.


GROUND
OIL PRESSURE SENSOR INPUT
B+
55
65
100
75
120
137
85

Courtesy of Chrysler Motors

e. Reverse procedure to replace unit.

3. Procedure for replacing oil pressure sending unit

a. Disconnect sending unit wiring.

b Select appropriate socket.

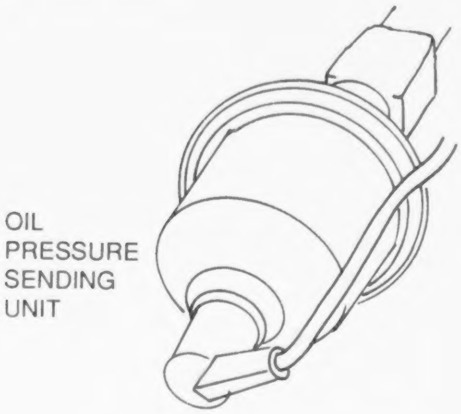
c. Remove sending unit (it will have to be unscrewed).

d. Clean engine block threads.

e. Coat threads of new sending unit with sealer.

f. Screw the sending unit into the block.

(NOTE: Over tightening the sending unit may cause it to fail.)



4. Procedure for replacing temperature sending unit

   a. Drain cooling system.

   b. Disconnect wiring from sensor

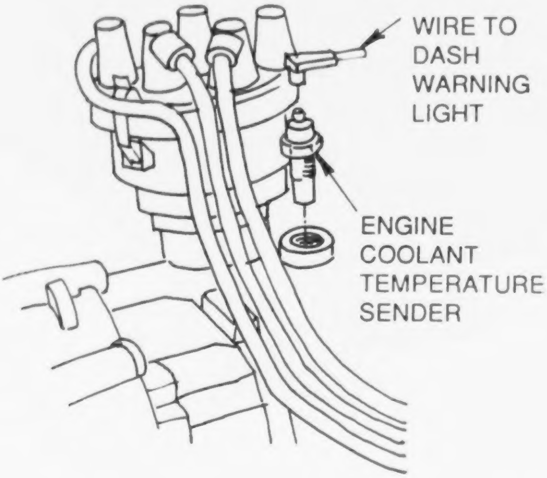
   c. Remove sending unit.

   d. Clean engine block threads

   e. Coat threads of new sending unit with sealer

f. Screw the sending unit into the block.

(NOTE: Over tightening the sending unit may cause it to fail.)

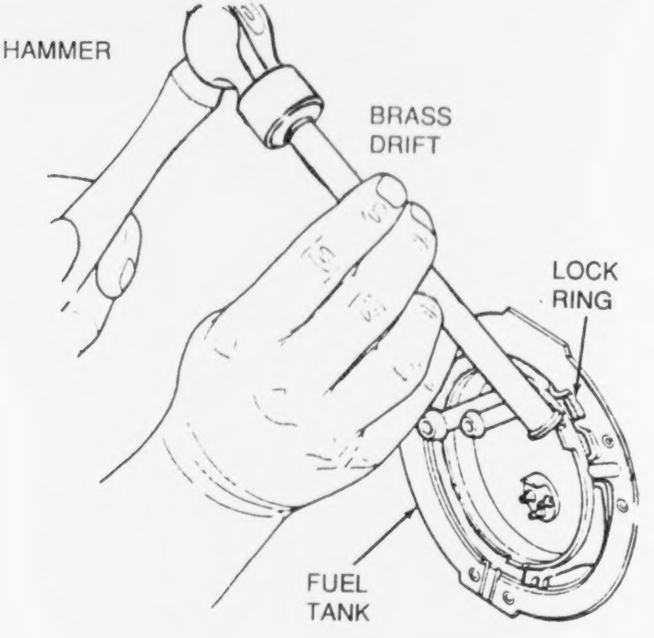

WIRE TO DASH WARNING LIGHT
ENGINE COOLANT TEMPERATURE SENDER

5. Procedure for replacing fuel tank sending unit

   a. Drain fuel.

   b. Remove tank.

c. Using a brass drift, rotate sending unit locking ring to unlocked position.



Courtesy of Chrysler Motors

d. Lift unit from the tank.

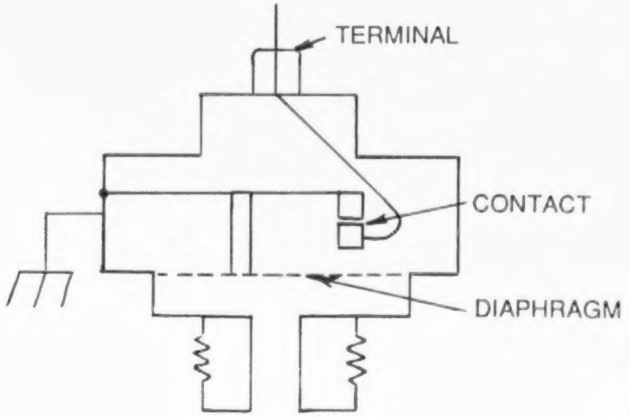
e. Reverse procedure to replace unit.

IV. Identifying driver information and warning systems

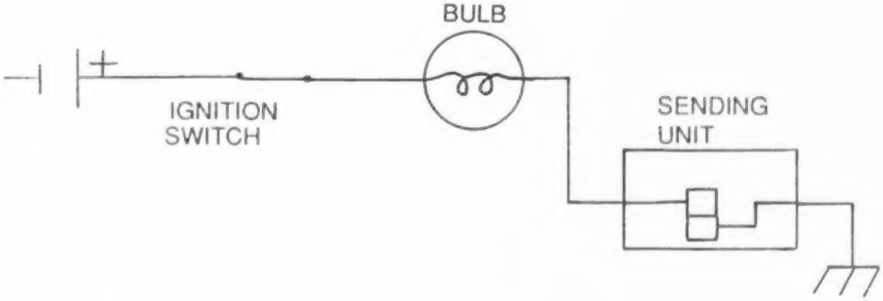
A. Illuminated information and warning system components and their circuits

1. A warning or information lamp indicates that a component in the vehicle requires immediate attention. The warning lamp's bulb is mounted behind a colored lens marked with a symbol indicating the warning.

2. The sending unit is usually a grounding switch that completes a circuit when a dangerous or undesirable condition arises in a vehicle.

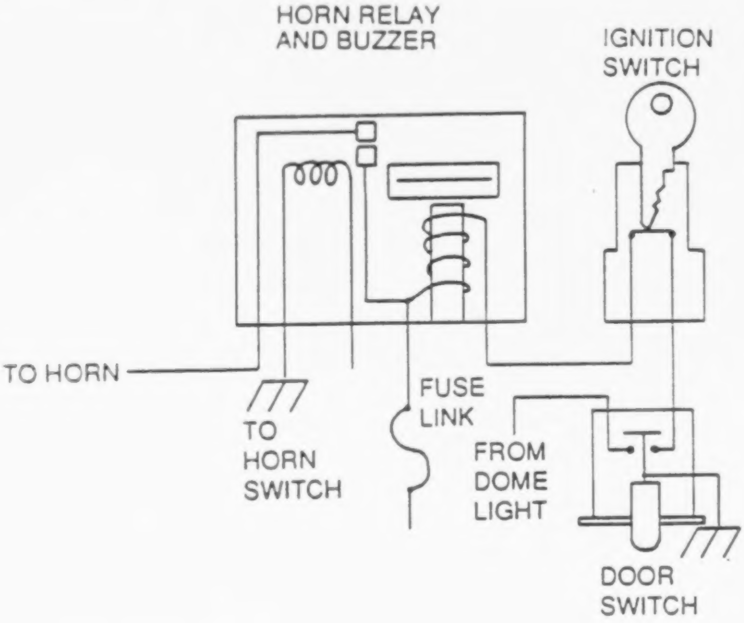

TERMINAL
CONTACT
DIAPHRAGM

3. Typical illuminated warning circuit

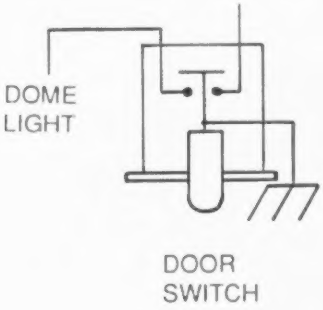

BULB
+
IGNITION SWITCH
SENDING UNIT

B. Audible warning or information components and circuits

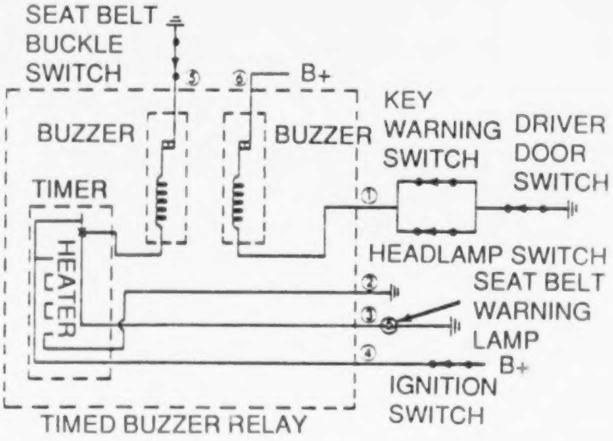
1. An audible warning device often uses a buzzer or bell that sounds for a predetermined time or until the undesirable condition is eliminated.


HORN RELAY AND BUZZER
IGNITION SWITCH
TO HORN
TO HORN SWITCH
FUSE LINK
FROM DOME LIGHT
DOOR SWITCH

2. A sending unit sounds the buzzer or bell in the warning device. The sending unit is usually a grounding switch that is activated by mechanical movement, such as a door opening or a key being put in the ignition.


DOME LIGHT
DOOR SWITCH

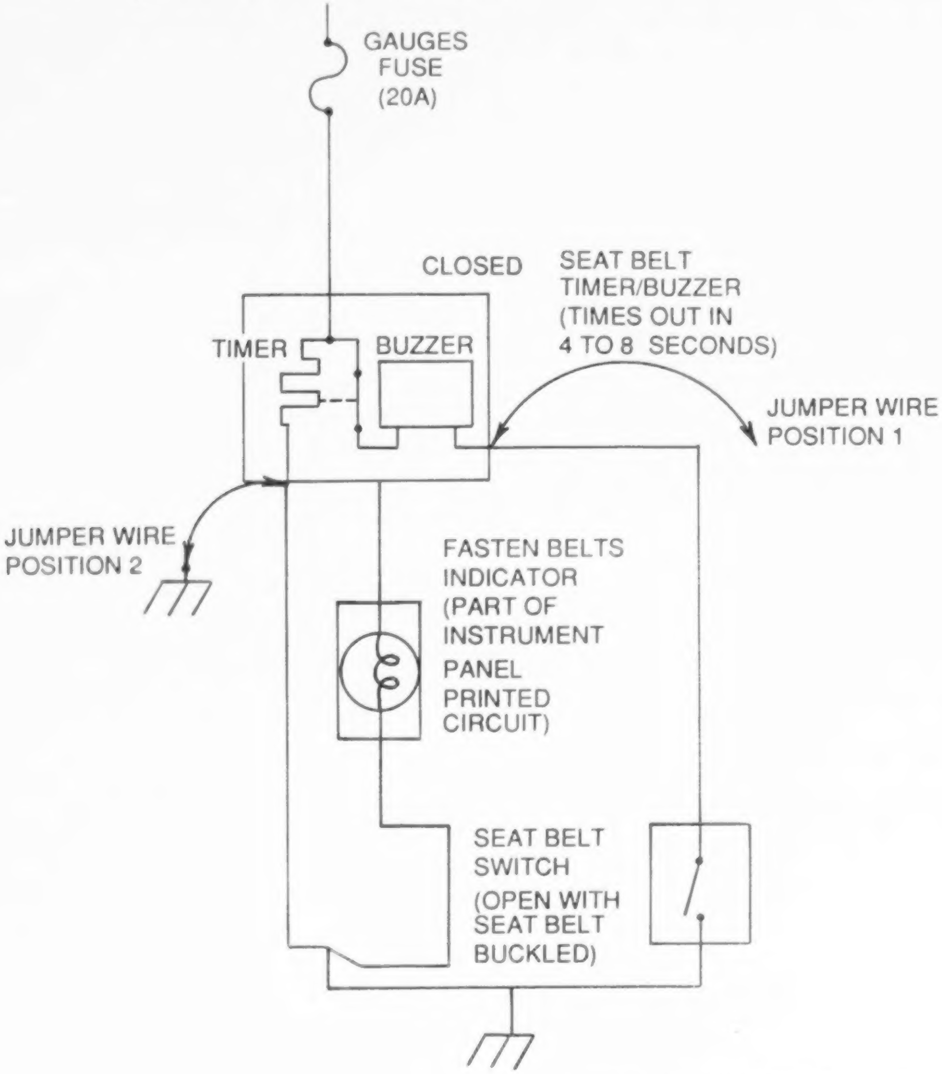
3. A timer device will maintain current flow to the buzzer for a predetermined time and then open the circuit until the next recycle.


SEAT BELT
BUCKLE
SWITCH
⑤
⑥
B+
BUZZER
BUZZER
KEY
WARNING
SWITCH
DRIVER
DOOR
SWITCH
TIMER
HEATER
①
HEADLAMP SWITCH
②
SEAT BELT
WARNING
LAMP
③
④
B+
IGNITION
SWITCH
TIMED BUZZER RELAY

Courtesy of Chrysler Motors

4. Some vehicles use a microcomputer system that produces an artificial or synthesized voice to warn of an undesirable condition.

5. Typical audible seat belt warning circuit


GAUGES
FUSE
(20A)
CLOSED
SEAT BELT
TIMER/BUZZER
(TIMES OUT IN
4 TO 8 SECONDS)
TIMER
BUZZER
JUMPER WIRE
POSITION 1
JUMPER WIRE
POSITION 2
FASTEN BELTS
INDICATOR
(PART OF
INSTRUMENT
PANEL
PRINTED
CIRCUIT)
SEAT BELT
SWITCH
(OPEN WITH
SEAT BELT
BUCKLED)

Courtesy of General Motors Corporation

V. Diagnosing, testing, repairing, and replacing a warning system

A. Testing information components and circuits

1. To test information lamps, use the same procedure as for testing dash lamps.

2. To test sending units, use the same procedure as for testing gauge systems.

3. Procedure for testing timer devices

a. Remove timer device.

b. Perform a resistance test across the timer circuit.

c. Meter reading should not be 0 or infinite.

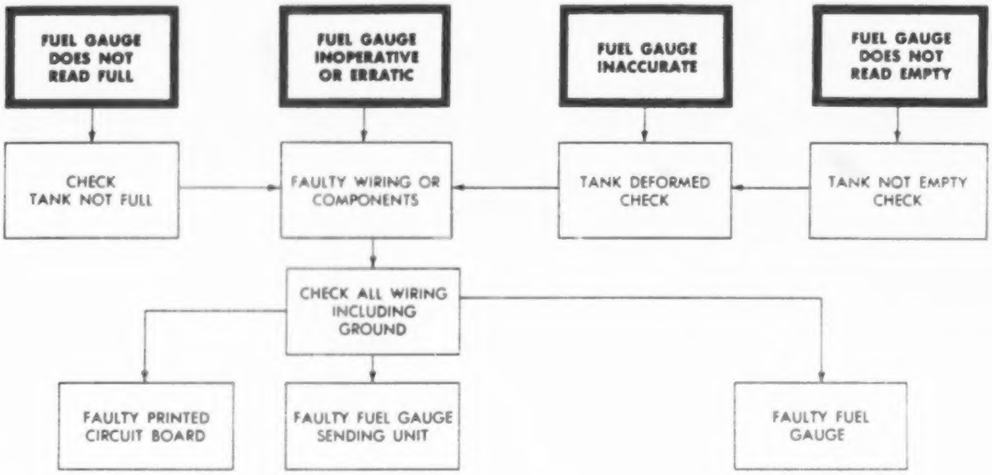
4. Procedure for replacing a buzzer

a. Disconnect buzzer.

b. Connect jumper leads.

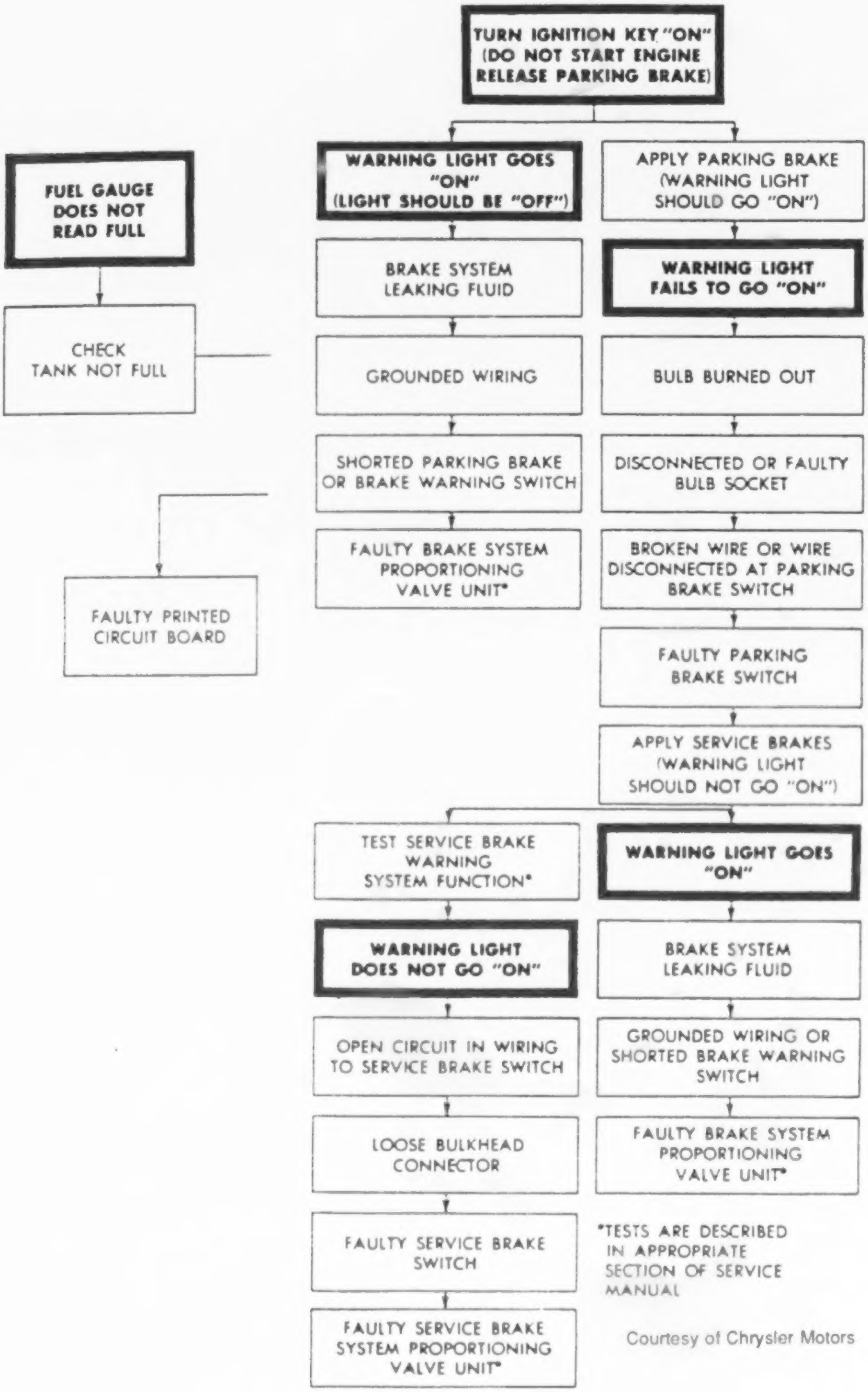
c. Buzzer should sound.

B. Fuel gauge circuit trouble shooting chart


FUEL GAUGE DOES NOT READ FULL
FUEL GAUGE INOPERATIVE OR ERRATIC
FUEL GAUGE INACCURATE
FUEL GAUGE DOES NOT READ EMPTY
CHECK TANK NOT FULL
FAULTY WIRING OR COMPONENTS
TANK DEFORMED CHECK
TANK NOT EMPTY CHECK
CHECK ALL WIRING INCLUDING GROUND
FAULTY PRINTED CIRCUIT BOARD
FAULTY FUEL GAUGE SENDING UNIT
FAULTY FUEL GAUGE

Courtesy of Chrysler Motors

C. Brake system warning lamp trouble shooting chart


TURN IGNITION KEY "ON" (DO NOT START ENGINE RELEASE PARKING BRAKE)
FUEL GAUGE DOES NOT READ FULL
CHECK TANK NOT FULL
FAULTY PRINTED CIRCUIT BOARD
WARNING LIGHT GOES "ON" (LIGHT SHOULD BE "OFF")
BRAKE SYSTEM LEAKING FLUID
GROUNDED WIRING
SHORTED PARKING BRAKE OR BRAKE WARNING SWITCH
FAULTY BRAKE SYSTEM PROPORTIONING VALVE UNIT*
APPLY PARKING BRAKE (WARNING LIGHT SHOULD GO "ON")
WARNING LIGHT FAILS TO GO "ON"
BULB BURNED OUT
DISCONNECTED OR FAULTY BULB SOCKET
BROKEN WIRE OR WIRE DISCONNECTED AT PARKING BRAKE SWITCH
FAULTY PARKING BRAKE SWITCH
APPLY SERVICE BRAKES (WARNING LIGHT SHOULD NOT GO "ON")
TEST SERVICE BRAKE WARNING SYSTEM FUNCTION*
WARNING LIGHT DOES NOT GO "ON"
OPEN CIRCUIT IN WIRING TO SERVICE BRAKE SWITCH
LOOSE BULKHEAD CONNECTOR
FAULTY SERVICE BRAKE SWITCH
FAULTY SERVICE BRAKE SYSTEM PROPORTIONING VALVE UNIT*
WARNING LIGHT GOES "ON"
BRAKE SYSTEM LEAKING FLUID
GROUNDED WIRING OR SHORTED BRAKE WARNING SWITCH
FAULTY BRAKE SYSTEM PROPORTIONING VALVE UNIT*
*TESTS ARE DESCRIBED IN APPROPRIATE SECTION OF SERVICE MANUAL

Courtesy of Chrysler Motors

AS1-L1-UXII

MODULE: ELECTRICAL SYSTEMS

PROCEDURES FOR DIAGNOSING GAUGE CIRCUITS

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for testing gauge sending units on the vehicle to be serviced.
3. Determine the location of the gauge circuit limiter on the vehicle to be serviced. Develop a written procedure for exposing printed circuit boards in the dash of the vehicle to be serviced.
4. Develop a written procedure for testing the gauge circuit voltage limiter on the vehicle to be serviced.

MODULE: ELECTRICAL SYSTEMS

PROCEDURES FOR DIAGNOSING INDICATOR LIGHT CIRCUITS

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for testing faulty indicator light sending units on the vehicle to be serviced.
3. Develop a written procedure for exposing printed circuit boards in the dash of the vehicle to be serviced.

MODULE: ELECTRICAL SYSTEMS

PROCEDURES FOR DIAGNOSING AUDIBLE WARNING DEVICE CIRCUITS

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for checking faulty sending units for audible warning devices on the vehicle to be serviced.

MODULE: ELECTRICAL SYSTEMS

DIAGNOSING AND REPAIRING INTERMITTENT HIGH AND LOW GAUGE READING OR NO GAUGE READING

Equipment:

Hand tools
Voltmeter
Ohmmeter
Test light
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, determine if the gauge circuit has a source of voltage. ___ ___ ___ ___

   a. Check for voltage in the circuit or circuits that supply current to the gauges.

      (HINT: Use an appropriate service manual to locate the fuses; then check the fuses with a test light.)

      Does the circuit(s) have current?

      Yes ___ No ___

   b. If the circuit(s) are dead, recommend steps to reinstate current flow.

3. Following the procedure outlined below, check for defective sending units. ___ ___ ___ ___

   (NOTE: If the problem occurs in all gauges, skip item three of this job sheet.)

   a. Complete items 1 and 2 of AS1-L1-UXII.

   b. Using the procedure developed in item 2 of AS1-L1-UXII, test any sending unit that may not be functioning properly. Record observations.

c. Recommend steps to correct the situation.

4. Following the procedure outlined below, check the gauge circuit voltage limiter and printed circuit board on the back of the dash. _ _ _ _

    a. Complete items 3 and 4 of AS1-L1-UXII.

    b. Following the procedure developed in item 3 of AS1-L1-UXII, expose the gauge circuit voltage limiter so that it can be tested.

    (**CAUTION**: Always remove the negative battery cable before removing dash.)

    c. Following the procedure developed in item 4 of AS1-L1-UXII, test the gauge circuit voltage limiter and record observations.

    d. Recommend steps to correct the situation.

    e. Visually inspect the printed circuit board for opens, bad connections or burns. Record observations.

    f. Check the printed circuit board with an ohmmeter. Record observations.

    (**CAUTION**: Make sure the gauge circuit does not have any voltage supplied to it during the ohmmeter test.)

g. Recommend steps to repair the printed circuit board.

Average of above evaluations* _ _ _ _

(*This average is a partial evaluation for Competency I1. Final evaluation for I1 will be made at the end of JS3-L1-UXII.)

JS2-L1-UXII

MODULE: ELECTRICAL SYSTEMS

DIAGNOSING AND REPAIRING INTERMITTENT OR CONSTANT INDICATOR LIGHT OR INDICATOR LIGHT THAT FAILS COMPLETELY

Equipment:

Hand tools
Voltmeter
Ohmmeter
Test light
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, determine if the vehicle's indicator light circuit has a source of voltage. ___ ___ ___ ___

   a. Check for voltage in the circuit or circuits that supply current to the indicator lights.

      (HINT: Use an appropriate service manual to locate the fuses; then check fuses with a test light.)

      Does the circuit(s) have voltage?

      Yes _ No _

   b. If the circuit(s) is dead, recommend steps to correct the problem.

3. Following the procedure outlined below, check for defective sending units. ___ ___ ___ ___

   a. Complete items 1 and 2 of AS2-L1-UXII.

   b. Using the procedure developed in item 2 of AS2-L1-UXII, check the operation of any defective sending unit. Record observations.

c. Recommend steps to correct the problem.

4. Following the procedure outlined below, check the printed circuit on the back of the dash of a car equipped with indicator lights. — — — —

   a. Complete item 3 of AS2-L2-UXII.

   b. Following the procedure developed in item 3 of AS2-L2-UXII, expose the dash printed circuit board so that it can be tested.

      (**CAUTION:** Always remove the negative battery cable before removing the dash.)

   c. Visually inspect the printed circuit board for opens, bad connections, or burns. Record observations.

   d. Check the printed circuit board terminals with an ohmmeter. Record observations.

      (**CAUTION:** Make sure the indicator light circuit does not have any voltage supplied to it during the ohmmeter test.)

   e. Recommend steps to repair the printed circuit board.

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency I1. Final evaluation for I1 will be made at the end of JS3-L1-UXII.)

JS3-L1-UXII

MODULE: ELECTRICAL SYSTEMS

DIAGNOSING AND REPAIRING INTERMITTENT OR CONSTANT FUNCTIONING OF AN AUDIBLE WARNING SYSTEM DEVICE OR THE FAILURE OF AN AUDIBLE WARNING SYSTEM DEVICE

Equipment:

Hand tools
Voltmeter
Ohmmeter
Test light
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Following the procedure outlined below, determine if the vehicle's audible warning device circuits have a source of voltage. __ __ __ __

   a. Check for voltage in the circuit or circuits that supply current to the gauges.

      (HINT: Use an appropriate service manual to locate the fuses; then check the fuses with a test light.)

      Does the circuit(s) have current?

      Yes __ No __

   b. If the circuit(s) are dead, recommend steps to reinstate current flow.

3. Following the procedure outlined below, check for defective sending units. __ __ __ __

   (NOTE: If the problem occurs in all audible warning system devices, skip this step.)

   a. Complete AS3-L1-UXII.

b. Using the procedure developed in item 2 of AS3-L1-UXII, check the operation of the sending unit that may not be functioning properly. Record observations.

c. Recommend steps to correct the problem.

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency I1. Final evaluation for I1 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency I1 by averaging the final evaluation of JS1-L1-UXII, JS2-L1-UXII, and JS3-L1-UXII. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS1-L1-UXII	—	—	—	—
JS2-L1-UXII	—	—	—	—
JS3-L1-UXII	—	—	—	—
Final evaluation for Competency I1	—	—	—	—

MODULE: ELECTRICAL SYSTEMS

UNIT XII: AUTOMOTIVE GAUGES, WARNING DEVICES, AND DRIVER INFORMATION SYSTEMS

UNIT XII TEST

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 1. In a bimetallic gauge, needle movement indicates varying amounts of current going to the circuit.

____ 2. In a bimetallic gauge, the bimetal strip moves the needle by way of a magnetic field.

____ 3. An instrument voltage regulator delivers regulated voltage to the gauge circuit.

____ 4. The magnetic gauge uses balancing coils and magnetic fields to move the indicator in relation to current flow through the gauge.

____ 5. In the magnetic gauge, the armature rotates in response to magnetic action.

____ 6. Sending units are used primarily in systems designed to warn of dangerously high temperatures.

____ 7. The instrument voltage regulator maintains an average of 10 volts of current flow to the gauge circuit.

____ 8. A thermistor varies its resistance in relation to current surges.

____ 9. The instrument voltage regulator is mounted either on or near the alternator.

____ 10. When replacing an instrument voltage regulator or a gauge unit, the technician should always disconnect the negative battery cable first.

____ 11. A fuel gauge is either a bimetallic or magnetic gauge.

____ 12. Seat belt warning devices are time delayed.

____ 13. A problem in a sending unit could cause a single gauge to malfunction.

SECTION B. **Select the best answer from the five choices listed.**

____ 14. The instrument voltage regulator is

a. a load-control device.
b. an insulating device.
c. a type of printed circuit board.
d. all of the above.
e. none of the above.

____ 15. A potentiometer varies resistance by using

a. a magnetic field.
b. a bimetal strip wrapped in aluminum.
c. an iron bar and a sliding aluminum housing.
d. an iron bar and a sliding tungsten steel housing.
e. a wrapped coil and a sliding contact.

____ 16. When replacing the instrument voltage regulator, the technician must remove

a. the instrument cluster only.
b. the alternator only.
c. both the instrument cluster and the alternator.
d. neither the instrument cluster nor the alternator.
e. the battery.

____ 17. The bulb in an automotive warning lamp is

a. made of tinted glass.
b. made of tinted plastic.
c. mounted behind a colored lens.
d. surrounded with reflective metal.
e. mounted behind a clear lens.

____ 18. The sending unit is usually a

a. printed circuit board.
b. transistor.
c. type of fuse.
d. type of circuit breaker.
e. grounding switch.

____ 19. In some vehicles, artificial or synthesized voices warn drivers of a condition that needs attention. These voices are produced by

a. a digital recording device.
b. a cassette tape enclosed in the dash.
c. a microcomputer system.
d. modulation of radio transistors.
e. none of the above.

SECTION C. Read each of the below statements made by technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.

____ 20. Technician I says that an excess of water in a vehicle's fuel tank can cause a fuel gauge to give low readings.

Technician II says that certain weather conditions may cause a fuel gauge to give incorrect readings.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I nor II

___ 21. Technician I says that a deformed fuel tank can cause a fuel gauge to operate erratically or to stop functioning.

Technician II says that a faulty fuel gauge sending unit can cause a fuel gauge to operate erratically or cease functioning completely.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

___ 22. Technician I says that a faulty printed circuit board can cause a fuel gauge to give inaccurate readings.

Technician II says that faulty wiring or component failure within a fuel gauge circuit can cause a fuel gauge to give inaccurate readings.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

___ 23. Technician I says that, if the fuel gauge does not read empty when the fuel tank is known to be empty, the cap on the fuel tank may not be tightened down securely.

Technician II says that, if the fuel gauge does not read empty when the fuel tank is known to be empty, a vacuum may have formed within the tank.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

___ 24. Technician I says that, if the brake warning light comes on when the ignition key is in the "on" position and the parking brake is released, the brake system may be leaking fluid.

Technician II says that, if the brake warning light fails tc come on when the parking brake is applied and the ignition key is in the "on" position, the warning-light bulb may be burned out.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

___ 25. Technician I says that, if a slow-acting instrument voltage regulator causes rapid vibration of the needle gauge, the regulator should be adjusted.

Technician II says that, if all gauges fail to function, the individual gauge needles should be checked first.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of _____ on the Unit XII Test in order to receive an evaluation for Competency I1.)

ANSWERS TO UNIT XII TEST

1. t
2. f
3. t
4. t
5. t
6. f
7. t
8. f
9. f
10. t
11. t
12. t
13. t
14. a
15. e
16. a
17. c
18. e
19. c
20. d
21. c
22. c
23. d
24. c
25. d

MODULE: ELECTRICAL SYSTEMS

UNIT XIII: THE HORN AND WIPER/WASHER SYSTEMS

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose and repair the horn and wiper/washer systems. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with the horn and wiper/washer systems (Competency I2, Unit XIII Test).

II. Identify horn system components and circuits (Competency I2, Unit XIII Test).

III. Identify procedures for diagnosing, testing, replacing, and repairing horn system components (Competency I2, Unit XIII Test).

IV. Identify wiper/washer system components and circuits (Competency I2, Unit XIII Test).

V. Identify procedures for diagnosing and testing the wiper/washer system circuits (Competency I2, Unit XIII Test).

VI. Demonstrate the ability to:

   a. Diagnose and repair constant or intermittent horn operation or horn failure (Competency I2, JS1-L1-UXIII).

   b. Diagnose and repair constant or intermittent wiper action or wiper failure (Competency I2, JS2-L1-UXIII).

   c. Diagnose and repair constant or intermittent windshield washer action or windshield washer failure (Competency I2, JS3-L1-UXIII).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit can be adapted to cover ASE tasks F072-F077 and F079 and F080.

MODULE: ELECTRICAL SYSTEMS

UNIT XIII: THE HORN AND WIPER/WASHER SYSTEMS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1 Lesson 1: DIAGNOSING AND REPAIRING THE HORN AND WIPER/WASHER SYSTEM

    a. Information outline

    b. Assignment sheets

      AS1-L1-UXIII: Diagnosing Horn Circuits
      AS2-L1-UXIII: Diagnosing Windshield Wipers
      AS3-L1-UXIII: Diagnosing Windshield Washers

    c. Job sheets

      JS1-L1-UXIII: Diagnosing and Repairing Constant or Intermittent Horn Operation or Horn Failure
      JS2-L1-UXIII: Diagnosing and Repairing Constant or Intermittent Windshield Wiper Action or Wiper Failure
      JS3-L1-UXIII: Diagnosing and Repairing Constant or Intermittent Windshield Washer Action or Windshield Washer Failure

E. Unit test

F. Answers to unit test

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Mitchell Information Services, Inc. 1986 Domestic Cars Tune up Mechanical Service and Repair. San Diego: Mitchell Information Services, Inc., 1986.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L1-UXIII in conjunction with JS1-L1-UXIII; AS2-L1-UXIII in conjunction with JS2-L1-UXIII; and AS3-L1-UXIII in conjunction with JS3-L1-UXIII.

MODULE: ELECTRICAL SYSTEMS

UNIT XIII: THE HORN AND WIPER/WASHER SYSTEMS

LESSON 1: DIAGNOSING AND REPAIRING THE HORN AND WIPER/WASHER SYSTEM

I. Terms and definitions

A. Cycling (park) switch--An automatic switch that returns the wiper motor to the parked position after the motor is turned off.

B. Grounding horn contact switch--A grounding switch that activates the horn relay.

C. Horn--A device which uses a metal diaphragm to produce sound.

D. Horn relay--A device that allows heavy current to flow to the horn. The relay is controlled by the horn grounding switch.

E. Intermittent wipers--Wipers that operate at intervals.

F. Tone adjustment--An adjustment screw located on the horn. The tone adjustment controls the frequency and current draw of the horn.

G. Washer--Either an external or internal pump that sprays washer fluid on the windshield. The washer is directly controlled by the vehicle's driver.

H. Wiper blade--A rubber replacement insert on the wiper arm. The blade wipes the windshield clean.

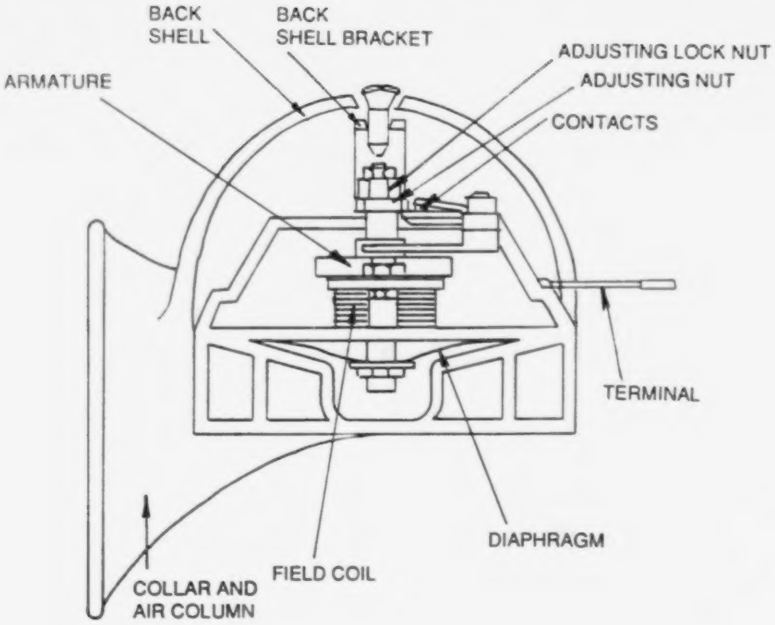
I. Wiper control switch--A switch that controls wiper and washer operation.

J. Wiper motor--A multiple-speed electric motor that moves the wiper arms.

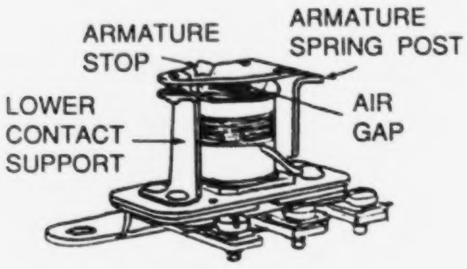
II. Horn system components and circuits

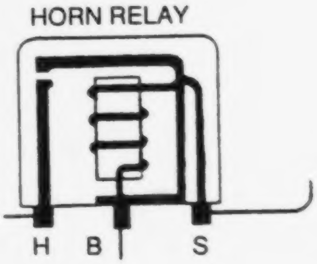
A. Horn system components

1. The horn uses an oscillating iron core that is pulled back and forth by a magnetic field coil. A set of cycling contacts reverses the direction of the iron core at the end of each stroke. The iron core is attached to a metal diaphragm. The movement of the iron core (armature) produces air shock waves, which create sound. A tone-adjusting screw dampens the diaphragm's movement and changes its tone.


BACK SHELL
BACK SHELL BRACKET
ADJUSTING LOCK NUT
ADJUSTING NUT
ARMATURE
CONTACTS
TERMINAL
DIAPHRAGM
FIELD COIL
COLLAR AND AIR COLUMN

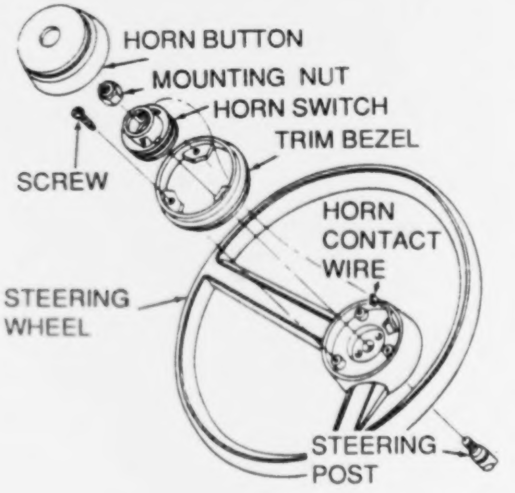
2. In most horn systems, an electromechanical relay is required to control heavy current flow. The relay coil itself is controlled by a small wire, which runs up the column and which is grounded by the horn button.


ARMATURE STOP
ARMATURE SPRING POST
AIR GAP
LOWER CONTACT SUPPORT


HORN RELAY
H
B
S

Reproduced by permission.
Crouse, W.H. **AUTOMOTIVE ELECTRONICS AND ELECTRICAL EQUIPMENT**.
10th ed. New York: McGraw-Hill Book Company, 1986.

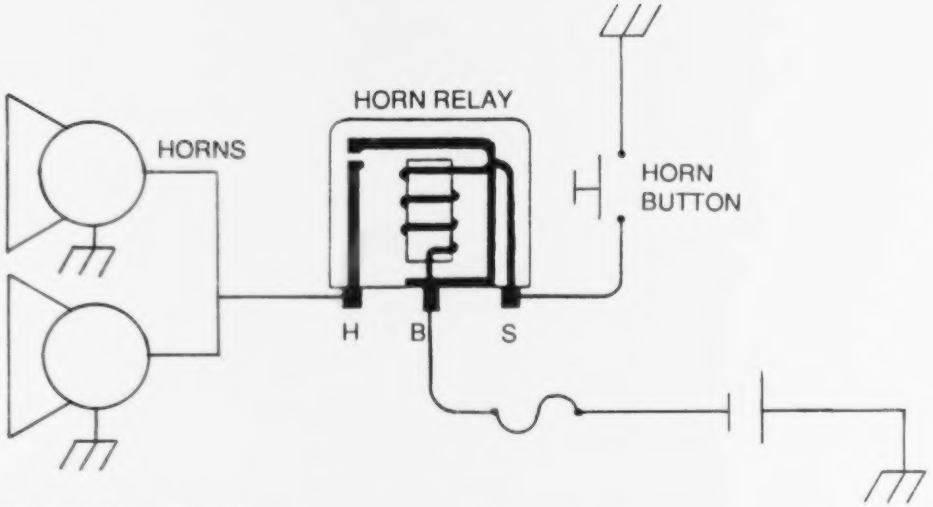
3. The grounding horn switch completes the relay coil circuit, thus allowing it current.


HORN BUTTON
MOUNTING NUT
HORN SWITCH
TRIM BEZEL
SCREW
HORN CONTACT WIRE
STEERING WHEEL
STEERING POST

Courtesy of Chrysler Motors

B. The horn circuit

1. Relay type


HORN RELAY
HORNS
HORN BUTTON
H
B
S

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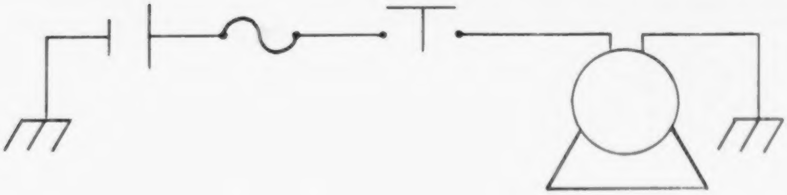
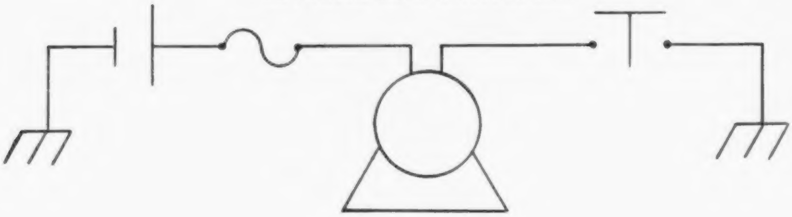
Crouse, W.H. **AUTOMOTIVE ELECTRONICS AND ELECTRICAL EQUIPMENT**
10th ed. New York: McGraw-Hill Book Company, 1986.

2. Nonrelay type

POWER SIDE SWITCHED



GROUND SIDE SWITCHED

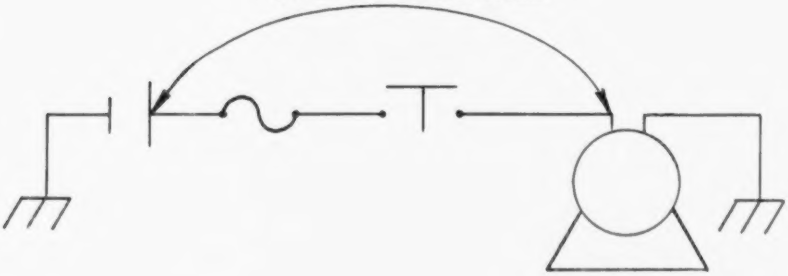


III. Diagnosing, testing, replacing, and repairing horn components

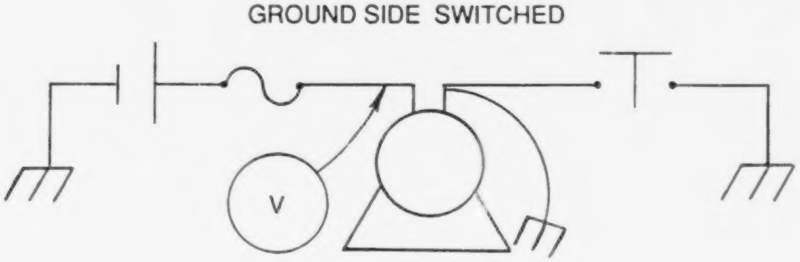
A. Testing horn system components

1. In order to test a horn that is power-side switched, connect a jumper wire to the battery positive terminal and to the horn's B+ terminal. Doing so should allow the horn to sound.

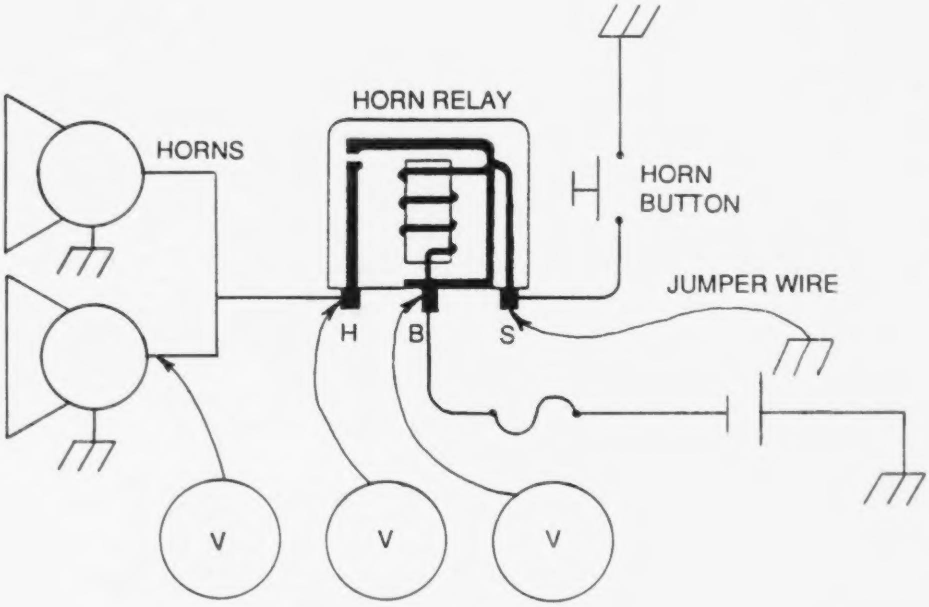
POWER SIDE SWITCHED



2. In order to test a horn that is ground-side switched, first confirm that the horn has a reliable source of voltage. If a reliable voltage source is confirmed, connect a jumper wire from the horn's negative terminal to a good ground. Doing so should cause the horn to sound.


GROUND SIDE SWITCHED
V

3. To test the relay, connect a jumper lead from the switch terminal to ground. Doing so should allow the horn to sound.


HORN RELAY
HORNS
HORN BUTTON
JUMPER WIRE
H
B
S
V
V
V

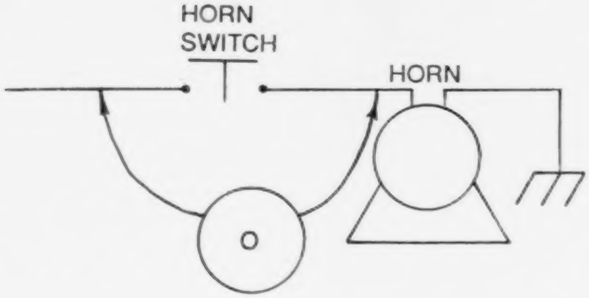
4. Procedure for horn circuit resistance test

   a. Remove the negative battery cable.

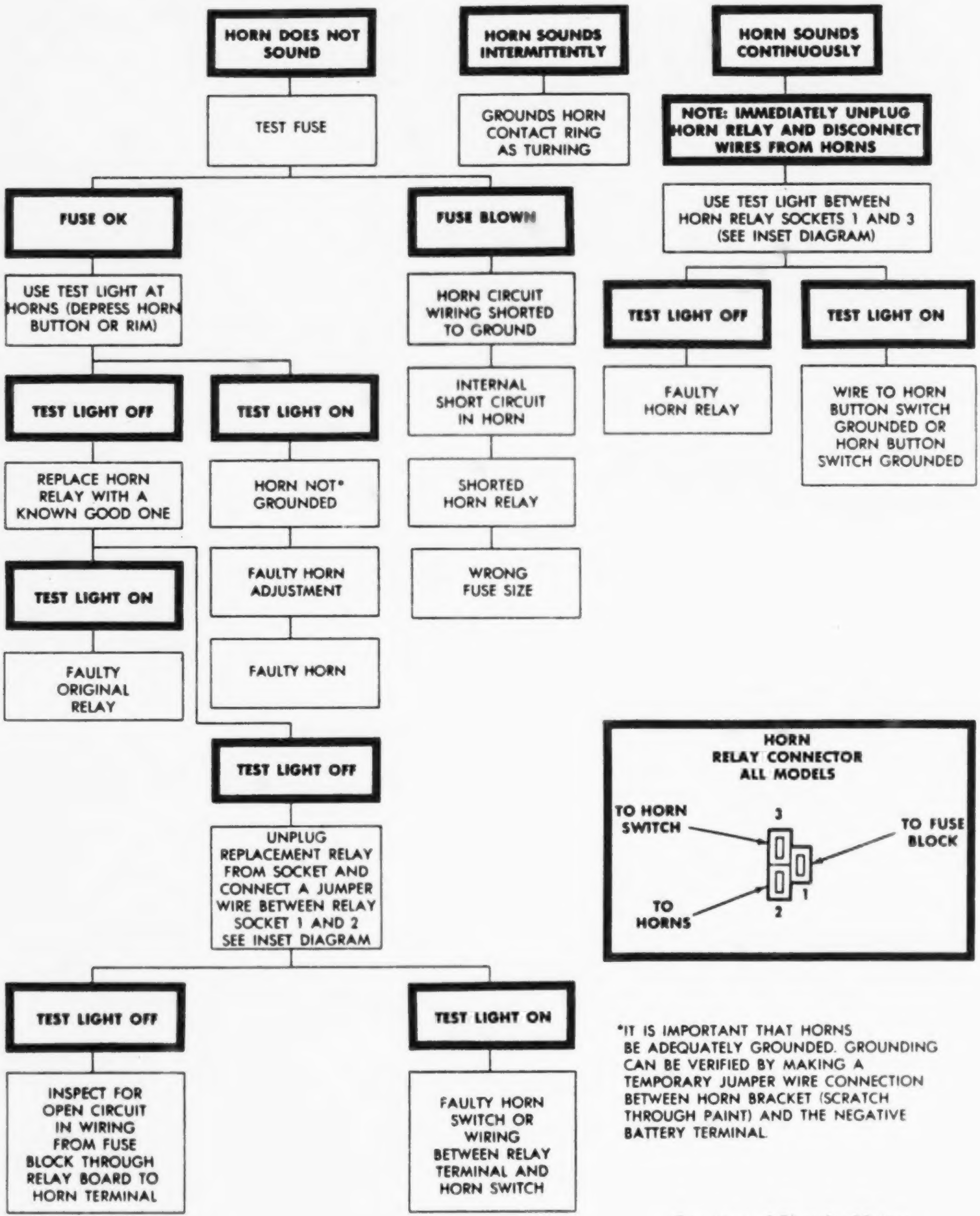
   b. Disconnect switch wire from the terminal.

   c. Connect one lead of the ohmmeter to the disconnected lead and the other to ground.

d. Push the horn button and take a reading. The reading should be 0.


HORN
SWITCH
HORN
O

B. Horn diagnostic chart


HORN DOES NOT SOUND
TEST FUSE
FUSE OK
USE TEST LIGHT AT HORNS (DEPRESS HORN BUTTON OR RIM)
TEST LIGHT OFF
REPLACE HORN RELAY WITH A KNOWN GOOD ONE
TEST LIGHT ON
FAULTY ORIGINAL RELAY
TEST LIGHT OFF
UNPLUG REPLACEMENT RELAY FROM SOCKET AND CONNECT A JUMPER WIRE BETWEEN RELAY SOCKET 1 AND 2 SEE INSET DIAGRAM
TEST LIGHT OFF
INSPECT FOR OPEN CIRCUIT IN WIRING FROM FUSE BLOCK THROUGH RELAY BOARD TO HORN TERMINAL
TEST LIGHT ON
FAULTY HORN SWITCH OR WIRING BETWEEN RELAY TERMINAL AND HORN SWITCH
TEST LIGHT ON
HORN NOT* GROUNDED
FAULTY HORN ADJUSTMENT
FAULTY HORN
FUSE BLOWN
HORN CIRCUIT WIRING SHORTED TO GROUND
INTERNAL SHORT CIRCUIT IN HORN
SHORTED HORN RELAY
WRONG FUSE SIZE
HORN SOUNDS INTERMITTENTLY
GROUNDS HORN CONTACT RING AS TURNING
HORN SOUNDS CONTINUOUSLY
NOTE: IMMEDIATELY UNPLUG HORN RELAY AND DISCONNECT WIRES FROM HORNS
USE TEST LIGHT BETWEEN HORN RELAY SOCKETS 1 AND 3 (SEE INSET DIAGRAM)
TEST LIGHT OFF
FAULTY HORN RELAY
TEST LIGHT ON
WIRE TO HORN BUTTON SWITCH GROUNDED OR HORN BUTTON SWITCH GROUNDED
HORN RELAY CONNECTOR ALL MODELS
TO HORN SWITCH
3
TO FUSE BLOCK
1
TO HORNS
2

*IT IS IMPORTANT THAT HORNS BE ADEQUATELY GROUNDED. GROUNDING CAN BE VERIFIED BY MAKING A TEMPORARY JUMPER WIRE CONNECTION BETWEEN HORN BRACKET (SCRATCH THROUGH PAINT) AND THE NEGATIVE BATTERY TERMINAL.

Courtesy of Chrysler Motors

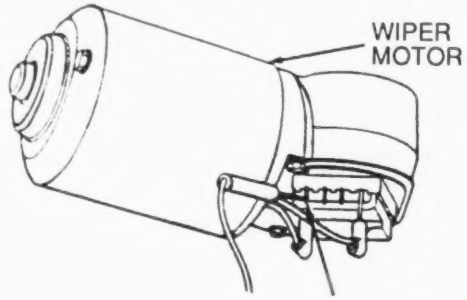
IV. Identifying wiper/washer components and circuits

A. Wiper/washer components

1. Some wiper motors have integral washer pumps and others do not.

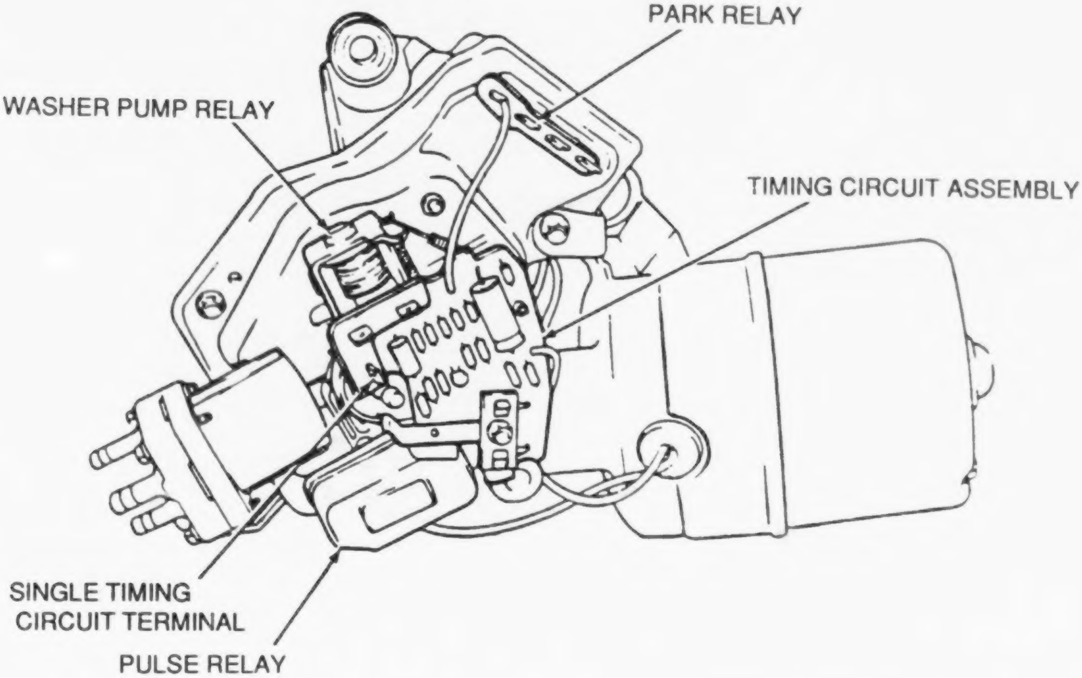
a. The multiple-speed-no-washer motor is, in most respects, a standard two or three-speed motor. The motor does, however, have a park-cycling switch, which keeps the motor running until the wipers reach the park position.

(NOTE: The park-cycling switch allows the wiper motor to return the wipers to the park position even after the wiper-control switch has shut off the current.)



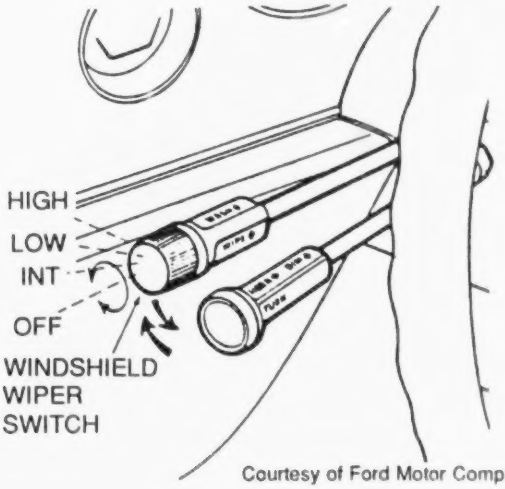
Courtesy of Chrysler Motors

b. The multiple-speed washer motor is a standard two or three-speed motor with the addition of an integral washer pump.


PARK RELAY
WASHER PUMP RELAY
TIMING CIRCUIT ASSEMBLY
SINGLE TIMING CIRCUIT TERMINAL
PULSE RELAY

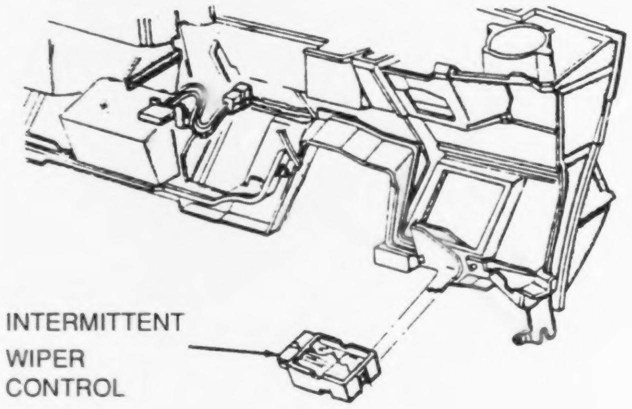
Courtesy of General Motors Corporation

2. Wiper control switches can be either dash or column mounted.

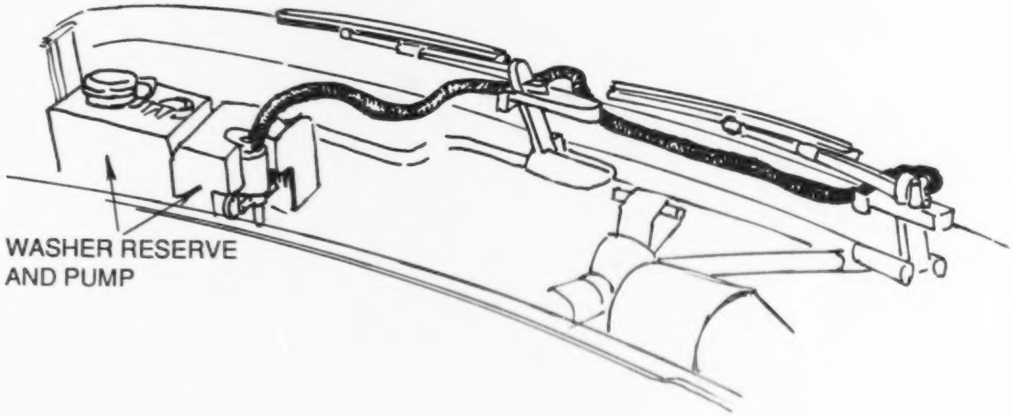

HIGH
LOW
INT
OFF
WINDSHIELD WIPER SWITCH

Courtesy of Ford Motor Company

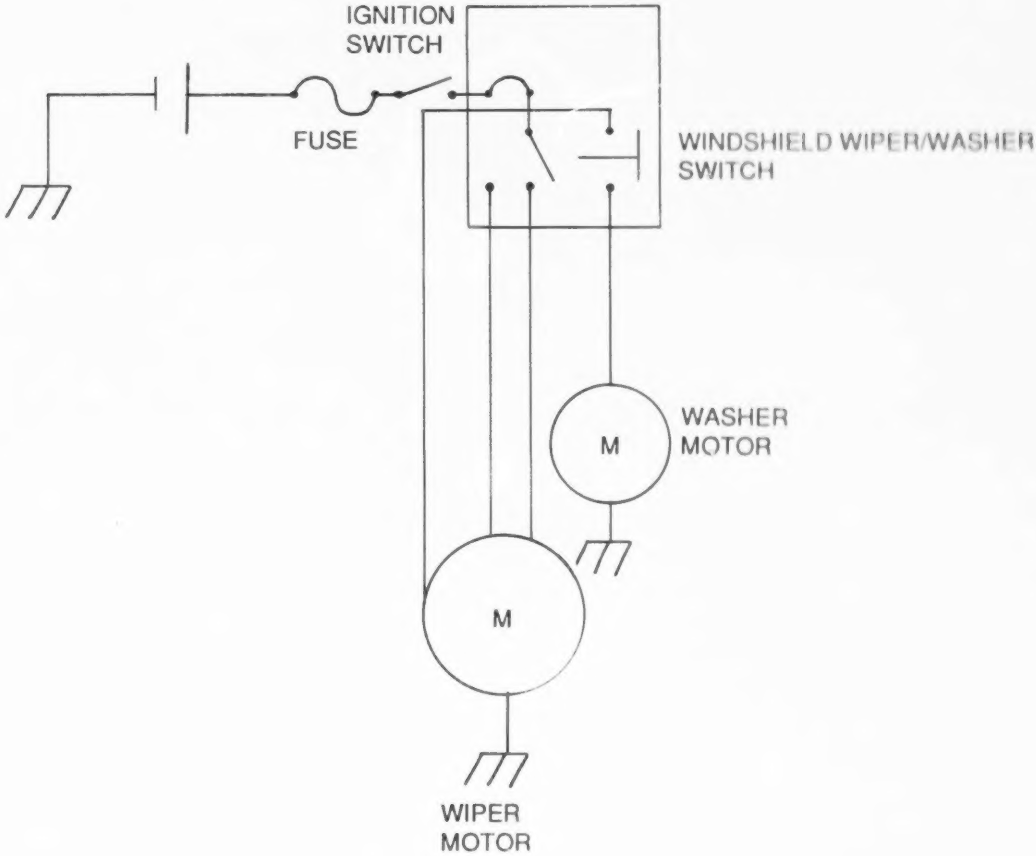
3. The intermittent control unit contains a variable timer circuit that intermittently turns the wiper motor off and on.


INTERMITTENT
WIPER
CONTROL

4. The washer motor is an electric pump operated by the wiper control switch. The washer motor sprays the windshield with washer fluid.


WASHER RESERVE
AND PUMP

5. The wiper and washer circuit


IGNITION SWITCH
FUSE
WINDSHIELD WIPER/WASHER SWITCH
WASHER MOTOR
M
M
WIPER MOTOR

V. Testing wiper/washer circuits

A. Component testing

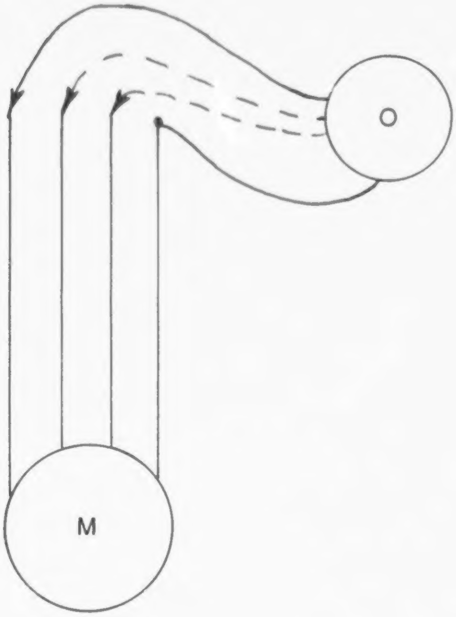
1. Procedure for testing the wiper motor

a. Disconnect wiper motor connector.

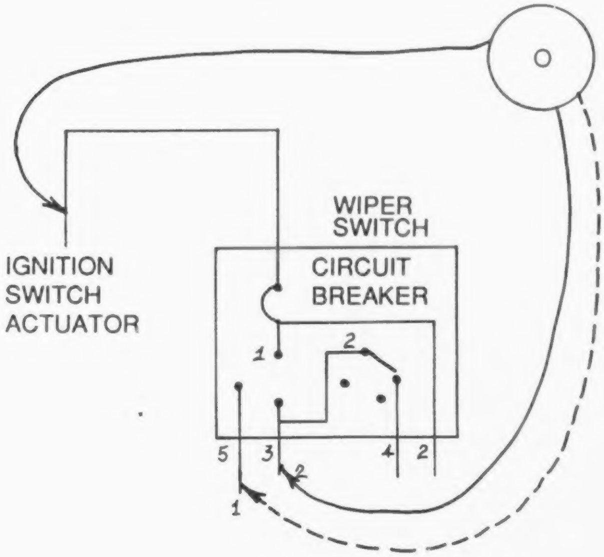
b. Connect an ohmmeter in parallel to the wiper motor.

c. Using Ohm's law, calculate resistance from the fuse size.

d. The ohmmeter reading should be greater than the maximum fuse size for each motor winding.



2. To determine continuity in the wiper-control switch, simply disconnect and resistance test the switch.


O
WIPER
SWITCH
IGNITION
SWITCH
ACTUATOR
CIRCUIT
BREAKER
2
1
5
3
4
2
2
1

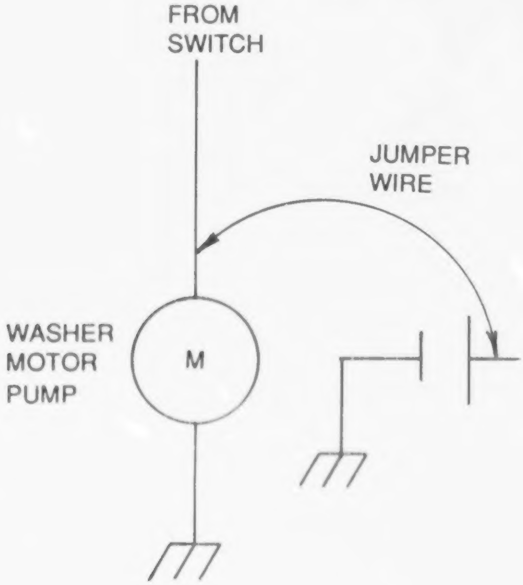
3. Procedure for testing a washer circuit (washer motor).

   a. Disconnect wiring connector.

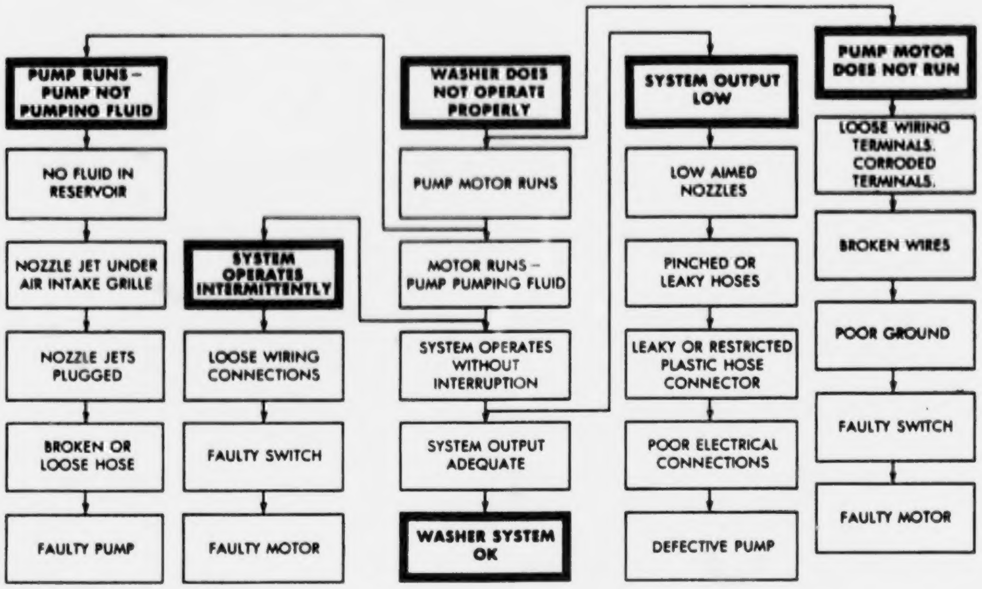
   b. Attach jumper from B+ to washer terminal.

   c. Ground other terminal.

   d. The pump should now run.

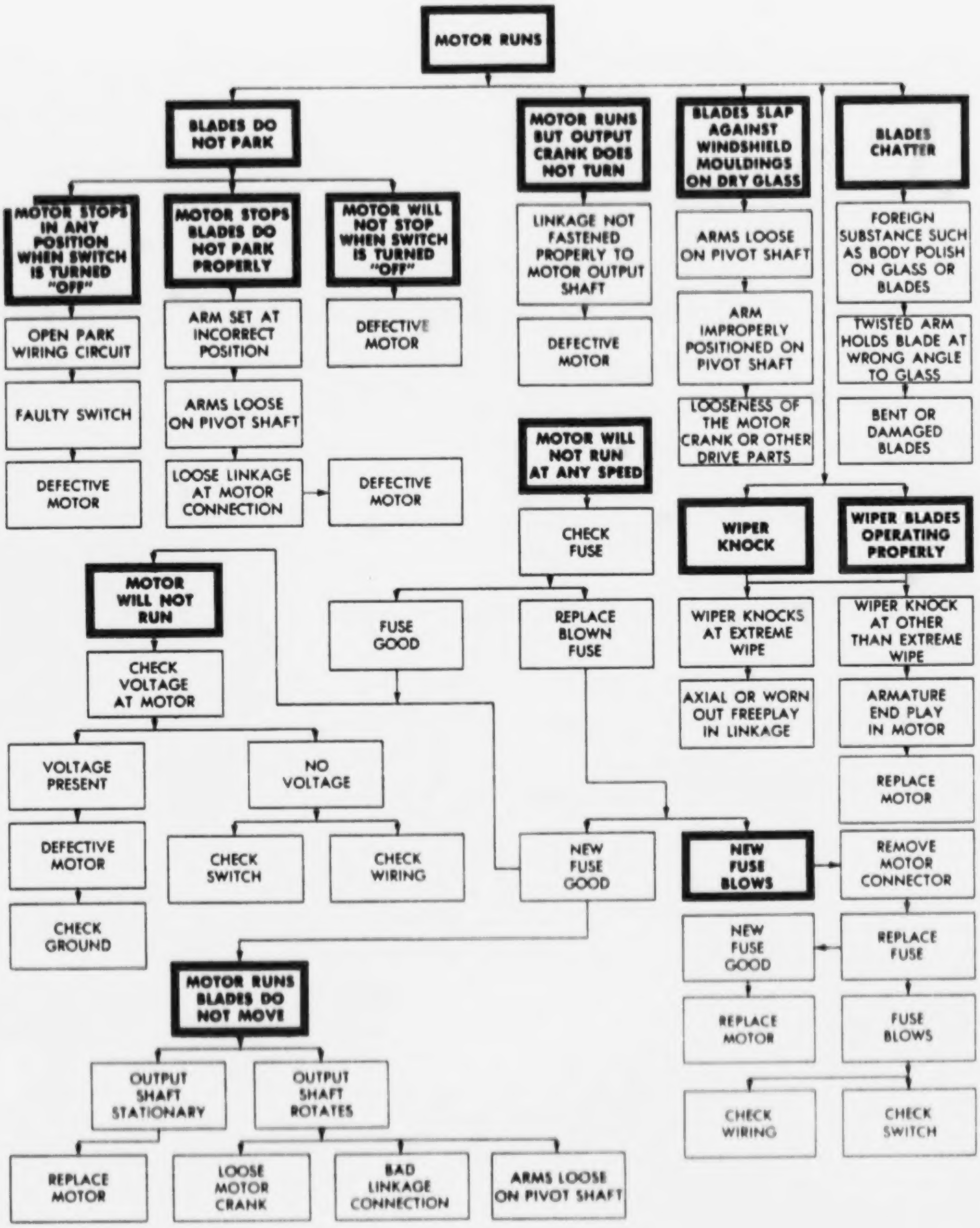

FROM SWITCH
JUMPER WIRE
WASHER MOTOR PUMP
M

B. Windshield washer diagnostic chart


PUMP RUNS – PUMP NOT PUMPING FLUID
NO FLUID IN RESERVOIR
NOZZLE JET UNDER AIR INTAKE GRILLE
NOZZLE JETS PLUGGED
BROKEN OR LOOSE HOSE
FAULTY PUMP
SYSTEM OPERATES INTERMITTENTLY
LOOSE WIRING CONNECTIONS
FAULTY SWITCH
FAULTY MOTOR
WASHER DOES NOT OPERATE PROPERLY
PUMP MOTOR RUNS
MOTOR RUNS – PUMP PUMPING FLUID
SYSTEM OPERATES WITHOUT INTERRUPTION
SYSTEM OUTPUT ADEQUATE
WASHER SYSTEM OK
SYSTEM OUTPUT LOW
LOW AIMED NOZZLES
PINCHED OR LEAKY HOSES
LEAKY OR RESTRICTED PLASTIC HOSE CONNECTOR
POOR ELECTRICAL CONNECTIONS
DEFECTIVE PUMP
PUMP MOTOR DOES NOT RUN
LOOSE WIRING TERMINALS, CORRODED TERMINALS.
BROKEN WIRES
POOR GROUND
FAULTY SWITCH
FAULTY MOTOR

Courtesy of Chrysler Motors

C. Windshield wiper diagnostic chart


MOTOR RUNS
BLADES DO NOT PARK
MOTOR RUNS BUT OUTPUT CRANK DOES NOT TURN
BLADES SLAP AGAINST WINDSHIELD MOULDINGS ON DRY GLASS
BLADES CHATTER
MOTOR STOPS IN ANY POSITION WHEN SWITCH IS TURNED "OFF"
MOTOR STOPS BLADES DO NOT PARK PROPERLY
MOTOR WILL NOT STOP WHEN SWITCH IS TURNED "OFF"
LINKAGE NOT FASTENED PROPERLY TO MOTOR OUTPUT SHAFT
ARMS LOOSE ON PIVOT SHAFT
FOREIGN SUBSTANCE SUCH AS BODY POLISH ON GLASS OR BLADES
OPEN PARK WIRING CIRCUIT
ARM SET AT INCORRECT POSITION
DEFECTIVE MOTOR
DEFECTIVE MOTOR
ARM IMPROPERLY POSITIONED ON PIVOT SHAFT
TWISTED ARM HOLDS BLADE AT WRONG ANGLE TO GLASS
FAULTY SWITCH
ARMS LOOSE ON PIVOT SHAFT
LOOSENESS OF THE MOTOR CRANK OR OTHER DRIVE PARTS
BENT OR DAMAGED BLADES
DEFECTIVE MOTOR
LOOSE LINKAGE AT MOTOR CONNECTION
DEFECTIVE MOTOR
MOTOR WILL NOT RUN AT ANY SPEED
CHECK FUSE
WIPER KNOCK
WIPER BLADES OPERATING PROPERLY
MOTOR WILL NOT RUN
FUSE GOOD
REPLACE BLOWN FUSE
WIPER KNOCKS AT EXTREME WIPE
WIPER KNOCK AT OTHER THAN EXTREME WIPE
CHECK VOLTAGE AT MOTOR
AXIAL OR WORN OUT FREEPLAY IN LINKAGE
ARMATURE END PLAY IN MOTOR
VOLTAGE PRESENT
NO VOLTAGE
REPLACE MOTOR
DEFECTIVE MOTOR
CHECK SWITCH
CHECK WIRING
NEW FUSE GOOD
NEW FUSE BLOWS
REMOVE MOTOR CONNECTOR
CHECK GROUND
NEW FUSE GOOD
REPLACE FUSE
MOTOR RUNS BLADES DO NOT MOVE
REPLACE MOTOR
FUSE BLOWS
OUTPUT SHAFT STATIONARY
OUTPUT SHAFT ROTATES
CHECK WIRING
CHECK SWITCH
REPLACE MOTOR
LOOSE MOTOR CRANK
BAD LINKAGE CONNECTION
ARMS LOOSE ON PIVOT SHAFT

Courtesy of Chrysler Motors

MODULE: ELECTRICAL SYSTEMS

DIAGNOSING HORN CIRCUITS

Instructions: **Do the tasks listed below on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for testing the vehicle's horn circuit.
3. Record the location of the vehicle's horn relay.
4. Develop a written procedure for testing the horn relay.

MODULE: ELECTRICAL SYSTEMS

DIAGNOSING WINDSHIELD WIPERS

Instructions: **Do the tasks listed below on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for lowering the windshield wiper switch so that it can be tested.
3. Make a drawing of the windshield wiper switch. Make sure the drawing clearly shows the switch wiring. On the drawing, indicate what component each wire serves.
4. Develop a written procedure for checking the operation of the windshield wiper switch.
5. Develop a written procedure for checking the operation of the vehicle's windshield wiper motor.

   (NOTE: If the wiper motor must be removed before it can be checked, include the procedure for doing so in the response to item 5 above.)

MODULE: ELECTRICAL SYSTEMS

DIAGNOSING WINDSHIELD WASHERS

Instructions: **Do the tasks listed below on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.

2. Develop a written procedure for lowering the windshield washer switch so that it can be tested.

   (NOTE: If the washer motor must be removed before it can be checked, include this procedure in the response to item 2 above.)

3. Make a drawing of the windshield washer switch. Make sure the drawing clearly shows the switch wiring. On the drawing, indicate what component each wire serves.

4. Develop a written procedure for checking the operation of the vehicle's windshield washer switch.

5. Develop a written procedure for checking the operation of the vehicle's windshield washer motor.

MODULE: ELECTRICAL SYSTEMS

DIAGNOSING AND REPAIRING CONSTANT OR INTERMITTENT HORN OPERATION OR HORN FAILURE

Equipment:

Hand tools
Voltmeter
Test light
Serviceable vehicle
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Following the procedure outlined below, determine if the vehicle's horn circuit has a source of voltage. __ __ __ __

   a. Check for voltage in the circuit or circuits that supply current to the horn.

      (HINT: Use an appropriate service manual to locate the fuses; then, check the fuses with a test light.)

      Does the circuit(s) have voltage?

      Yes __ No __

   b. Recommend steps to correct a circuit with no voltage.

   c. Disconnect the horn from the circuit.

   d. Connect voltmeter to the wire that was disconnected from the horn.

   e. Push the horn button on the steering wheel and observe voltmeter reading. Record the results below.

      (NOTE: Voltmeter should indicate a minimum of 11 volts for a 12-volt system.)

f. Recommend steps to correct any dead circuits.

3. Following the procedure outlined below, check for a defective horn relay. _ _ _ _

(NOTE: If the vehicle does not have a horn relay, skip this step.)

a. Complete items 1, 2, 3, and 4 of AS1-L1-UXIII.

b. Using the procedure developed in items 2, 3, and 4 of AS1-L1-UXIII, check the operation of the horn relay. Record the results below.

c. Recommend steps to correct any problems with the horn relay.

4. Following the procedure outlined below, check the operation of the horn(s). _ _ _ _

a. Complete item 5 of AS1-L1-UXIII.

b. Following the procedure developed in item 5 of AS1-L1-UXIII, determine if the horn is operating properly. Record the results below.

c. Recommend steps to correct any problems with the horn.

Average of the above evaluations* _ _ _ _

(*This average is a partial evaluation for Competency I2. Final evaluation for I2 will be made at the end of JS3-L2-UXIV.)

MODULE: ELECTRICAL SYSTEMS

DIAGNOSING AND REPAIRING CONSTANT OR INTERMITTENT WINDSHIELD WIPER ACTION OR WIPER FAILURE

Equipment:

Hand tools
Voltmeter
Ohmmeter
Test light
Serviceable vehicle
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Following the procedure outlined below, determine if the vehicle's wiper circuit has a source of voltage. __ __ __ __

   (NOTE: The below procedure is appropriate for either front or rear windshield wipers.)

   a. Check for voltage in the circuit or circuits that supply current to the wipers.

      (HINT: Use an appropriate service manual to locate the fuses, circuit breakers, or fusible links; then, check these items with a test light.)

      Does the circuit(s) have voltage?

      Yes __ No __

   b. Recommend steps to correct a circuit with no voltage.

c. Using the chart below, indicate if the wiper motor works in each mode.

Slow	Yes _	No _
Medium	Yes _	No _
High	Yes _	No _
Intermittent	Yes _	No _
Mist	Yes _	No _

d. Do the wiper blades retract all the way into the park position when the motor is turned off?

Yes _ No _

e. Is the linkage tight yet able to move freely?

Yes _ No _

f. Lube, adjust, and service linkage as needed.

g. Inspect the wiper blades and arms. Are they in good working order?

Yes _ No _

h. Recommend steps to correct any problems with the blades and arms.

3. Following the procedure outlined below, check the operation of the windshield wiper switch. _ _ _ _

a. Complete items 1, 2, 3, and 4 of AS2-L1-UXIII.

b. Following the procedure developed in item 2 of AS2-L1-UXIII, expose the windshield wiper switch so that it can be tested.

c. Following the procedure developed in items 3 and 4 of AS2-L1-UXIII, test the operation of the windshield wiper switch. Record the results below.

(NOTE: The windshield washer switch is an integral part of the windshield wiper switch. Both switches should be tested at this time.)

d. Recommend steps to correct any problems with the windshield wiper switch.

4. Following the procedure outlined below, check the operation of the windshield wiper motor. _ _ _ _

a. Complete AS2-L2-UXIII.

b. Following the procedure developed in item 5 of AS2-L1-UXIII, test the windshield wiper motor.

c. Recommend steps to correct any problems with the washer.

Average of the above evaluations* _ _ _ _

(*This average is a partial evaluation for Competency I2. Final evaluation for I2 will be made at the end of JS3-L2-UXIV.)

MODULE: ELECTRICAL SYSTEMS

DIAGNOSING AND REPAIRING CONSTANT OR INTERMITTENT WINDSHIELD WASHER ACTION OR WINDSHIELD WASHER FAILURE

Equipment:

Hand tools
Voltmeter
Ohmmeter
Test light
Serviceable vehicle
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. _ _ _ _

2. Following the procedure outlined below, determine if the vehicle's windshield washer circuit has a source of voltage. _ _ _ _

   (NOTE: This procedure is appropriate for either front or rear windshield wipers.)

   a. Check for voltage in the circuit or circuits that supply current to the windshield washer circuits.

      (HINT: Use an appropriate service manual to locate the fuses, circuit breakers, or fusible links; then, check these items with a test light.)

      Does the circuit(s) have voltage?

      Yes _ No _

   b. Recommend steps to correct a circuit with no voltage.

   c. Check solvent level in the windshield washer. Add solvent as needed.

   d. Make a visual inspection of all windshield washer hoses and spray nozzles. Record the results below.

e. Recommend steps to correct any problems with the washer hoses and spray nozzles.

3. Following the procedure outlined below, check the operation of the windshield washer switch. ____

a. Complete items 1, 2, 3, and 4 AS3-L1-UXIII.

b. Following the procedure developed in items 2 , 3 and 4 of AS3-L1-UXIII, check the operation of the windshield wiper switch. Record the results below.

4. Following the procedure outlined below, check the operation of the windshield washer motor. ____

(NOTE: If this procedure was completed as a part of JS2-L1-UXIII, record the results in the appropriate space below.)

a. Complete item 5 AS3-L1-UXIII.

b. Following the procedure developed in item 5 of AS3-L1-UXIII, test the windshield washer motor.

c. Recommend steps to correct any problems with the washer.

Average of above evaluations* ____

(*This average is a partial evaluation for Competency I2. Final evaluation for I2 will be made at the end of JS3-L2-UXIV.)

MODULE: ELECTRICAL SYSTEMS

UNIT XIII: THE HORN AND WIPER/WASHER

UNIT XIII: TEST

DIAGNOSING AND REPAIRING THE HORN AND WIPER WASHER

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 1. The cycling (park) switch allows the wiper motor to return wipers to the park position, even after the wiper-control switch has cut power.

____ 2. The tone adjustment screw controls the frequency and current draw of the horn.

____ 3. In most horn systems, the relay coil is controlled by several heavy wires, which are wrapped around the steering column and are grounded by the steering wheel.

____ 4. The grounding-horn switch completes the relay coil circuit and thus energizes the horn circuit.

____ 5. Washer pumps usually are connected to a different circuit from the wiper motors.

____ 6. In later-model cars, wiper control switches are almost always mounted on the dash.

____ 7. The multiple-speed-no-washer motor is, in most respects, a standard two or three-speed motor.

____ 8. A resistance test will determine continuity in a wiper- control switch.

SECTION B. **Select the best answer from the five choices listed.**

____ 9. The horn has an oscillating iron core that is pulled back and forth by

a. alternating electrical current.
b. a magnetic field coil.
c. the vibration of the horn diaphragm.
d. the expansion and contraction of a thin strip of tungsten steel.
e. none of the above.

____ 10. The horn diaphragm is made of

a. a thin sheet of bakelite.
b. a thin sheet of vinyl.
c. a sheet of vinyl with small perforations.
d. metal.
e. rubber.

____ 11. A resistance test of a horn circuit should reveal that the circuit has

a. high resistance.
b. low resistance.
c. no resistance.
d. high resistance if the vehicle is using a double battery.
e. no resistance if the vehicle is using a double battery.

____ 12. In the wiper circuit, the function of the intermittent control unit is to

a. keep the wiper motor running until it reaches the park position.
b. block power surges that may occur when other accessory circuits are activated.
c. allow the wipers to function when the engine is turned off.
d. turn the wiper motor on and off intermittently.
e. do none of the above.

____ 13. When testing the wiper motor, the technician must use Ohm's law and calculate the resistance from the fuse size. When connected to the wiper motor, an ohmmeter should give a reading that is

a. greater than the maximum fuse size for each motor winding.
b. less than the maximum fuse size for each motor winding.
c. the same as the maximum fuse size for each motor winding.
d. exactly double the maximum fuse size for each motor winding.
e. exactly half the maximum fuse size for each motor winding.

____ 14. In the wiper system, the washer uses

a. an internal pump only.
b. an external pump only.
c. either an internal or an external pump.
d. neither an internal nor an external pump.
e. both an internal and an external pump at the same time.

____ 15. The horn diaphragm produces sound when

a. struck by air shock waves.
b. surges of electricity pass through it.
c. struck repeatedly by an armature.
d. rapidly expanded by heat.
e. undergoing none of the above.

SECTION C. **Read each of the below statements made by technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.**

____ 16. Technician I says that, if the horn does not sound and the fuse in the horn circuit is in good condition, a test light should be used to test the horn circuit.

Technician II says that a blown fuse in the horn circuit could result from a shorted horn relay.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 17. Technician I says that a blown fuse could cause the horn to sound continuously.

Technician II says that a faulty horn adjustment screw could make the horn sound intermittently.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 18. Technician I says that, if a jumper wire is connected to the battery positive terminal and to the horn B+ terminal, the horn should sound.

Technician II says that the horn relay can be tested by connecting a jumper lead from the switch terminal to the ground; doing so should allow the horn to sound.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 19. Technician I says that the negative battery cable should be removed before resistance testing the horn circuit.

Technician II says that there must be a good connection between the horn switch and the terminal if a test of the switch is to be accurate.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 20. Technician I says that, if the windshield wiper motor stops in the wrong position when the switch is turned off, the linkage between the wiper and the motor may not be fastened properly.

Technician II says that the most likely cause of clattering wiper blades is looseness of the motor crank or other drive parts.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 21. Technician I says that, if the wiper blades do not park properly when the wiper motor stops, the wiper arm may be set in an improper position.

Technician II says that torn or frayed wiring can cause the wiper motor to continue running after the switch is turned off.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 22. Technician I says that, if the wiper motor will not run, the voltage should be checked at the motor.

Technician II says that wiper arms that are loose on the pivot shaft may slap against the windshield moldings on dry glass.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 23. Technician I says that, if a washer pump runs yet fails to pump fluid, the wiring should be checked for loose connections.

Technician II says that a faulty switch can cause the windshield washer system to operate intermittently.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 24. Technician I says that pinched or leaky hoses can cause system output to be low.

Technician II says that a defective pump can cause system output to be low.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 25. Technician I says that a poor ground can cause a windshield washer pump not to run.

Technician II says that a faulty motor can cause the windshield washer system to operate intermittently.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of ______ on the Unit XIII Test in order to receive an evaluation for Competency I2.)

ANSWERS TO UNIT XIII TEST

1. t
2. t
3. f
4. t
5. f
6. f
7. t
8. t
9. b
10. d
11. b
12. d
13. a
14. c
15. a
16. c
17. d
18. c
19. a
20. d
21. a
22. c
23. b
24. c
25. c

MODULE: ELECTRICAL SYSTEMS

UNIT XIV: MISCELLANEOUS AUTOMOTIVE ACCESSORIES

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose, test, and repair automotive accessories. The student will demonstrate mastery of the material by achieving a score of ________ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify terms and definitions associated with automotive accessory systems (Competency I2, Unit XIV Test).

II. Identify accessory systems and typical components (Competency I2, Unit XIV Test).

Lesson 2. I. Identify typical accessory circuit design and the procedures for diagnosing and testing them (Competency I2, Unit XIV Test).

II. Demonstrate the ability to:

a. Test and service the radiator cooling fan and its circuit (Competency I2, JS1-L2-UXIV).

b. Testing and servicing the heater fan motor and its circuit (Competency I2, JS2-L2-UXIV).

c. Testing and servicing the radio circuit and related components (Competency I2, JS3-L2-UXIV).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit can be adapted to cover ASE Tasks F081--F0110.

MODULE: ELECTRICAL SYSTEMS

UNIT XIV: MISCELLANEOUS AUTOMOTIVE ACCESSORIES

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: AUTOMOTIVE ACCESSORY SYSTEMS AND THEIR COMPONENTS

    a. Information outline

  2. Lesson 2: DIAGNOSING AND TESTING AUTOMOTIVE ACCESSORY CIRCUITS

    a. Information outline

    b. Assignment sheets

      AS1-L2-UXIV: Procedure for Testing the Radiator Cooling Fan and Its Circuit
      AS2-L2-UXIV: Procedure for Testing the Heater Fan Motor and Its Circuit

    c. Job sheets

      JS1-L2-UXIV: Testing and Servicing the Radiator Cooling Fan and Its Circuit
      JS2-L2-UXIV: Testing and Servicing the Heater Fan Motor and Its Circuit
      JS3-L2-UXIV: Testing and Servicing the Radio Circuit and Related Components

E. Unit test

F. Answers to unit test

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NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L2-UXIV in conjunction with JS1-L2-UXIV and AS2-L2-UXIV in conjunction with JS2-L2-UXIV.

MODULE: ELECTRICAL SYSTEMS

UNIT XIV: MISCELLANEOUS ACCESSORIES

LESSON 1: AUTOMOTIVE ACCESSORY SYSTEMS AND THEIR COMPONENTS

I. Terms and definitions

A. Antitheft system--An alarm protection system, which includes the horn, ignition, and light systems.

B. Automatic locking system--An electrical system that operates the mechanical door locks.

C. Cigar lighter--A resistance heater used for lighting cigars and cigarettes.

D. Clock circuit--Circuit for an electromechanical or digital time piece.

E. Cruise control circuit--An electromechanical or electropneumatic system that automatically maintains vehicle speed.

F. Power antenna--An automotive antenna that is mechanically extended or retracted.

G. Power seats--Vehicle seats that are reclined or straightened by an electric motor.

H. Power sun roof--A vehicle sun roof that is opened or closed by an electric motor.

I. Power window--Vehicle windows that are opened or closed by an electric motor.

J. Resistance heaters--An electrically resistant device, which produces heat.

K. Sending unit device--An electrically resistant device, which controls current flow in a circuit.

L. Solenoid activators--A device that converts electrical energy into linear mechanical movement.

M. Transducer--An electrical device that activates a pneumatic system or a pneumatic device that activates an electrical system.

N. Window deicer--A resistance heater used to clear fog and frost from windows and mirrors.

II. Identifying automotive accessory systems

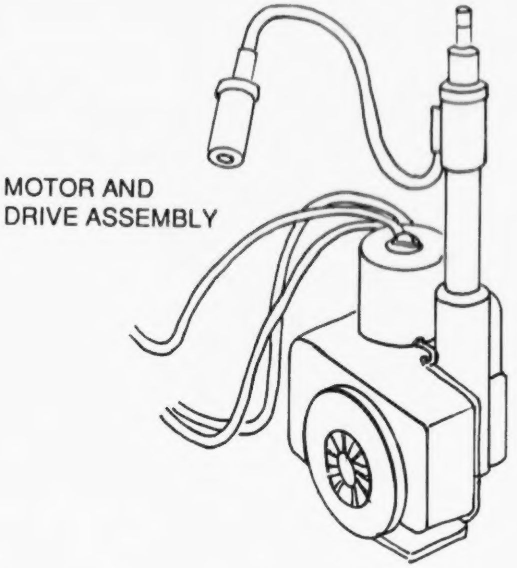
A. Each automotive accessory system falls into one of the following categories: motor-driven units, solenoid actuators, sending units, resistance heaters, electropneumatic devices, current-generating devices, and sound-producing systems. Each of these systems may have different designs, yet they all operate upon the same basic principles. This unit will examine the operating principle of each system and identify some of the typical circuits used by each.

B. Motor-driven accessory units

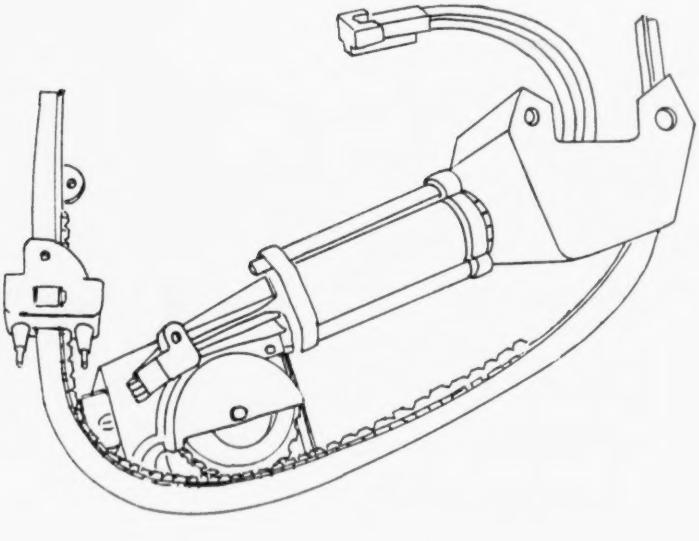
(NOTE: The following is a general description of motor-driven accessory units. Some characteristics of these units may vary, depending upon the model of vehicle.)

1. Motor-driven gear box devices use a single-speed or multiple-speed motor to drive a reduction gear assembly. The gear unit may drive either a linkage, screw thread, or cable. The motor-driven gear box is essentially a load device. Typical uses of the motor-driven gear box are listed below.

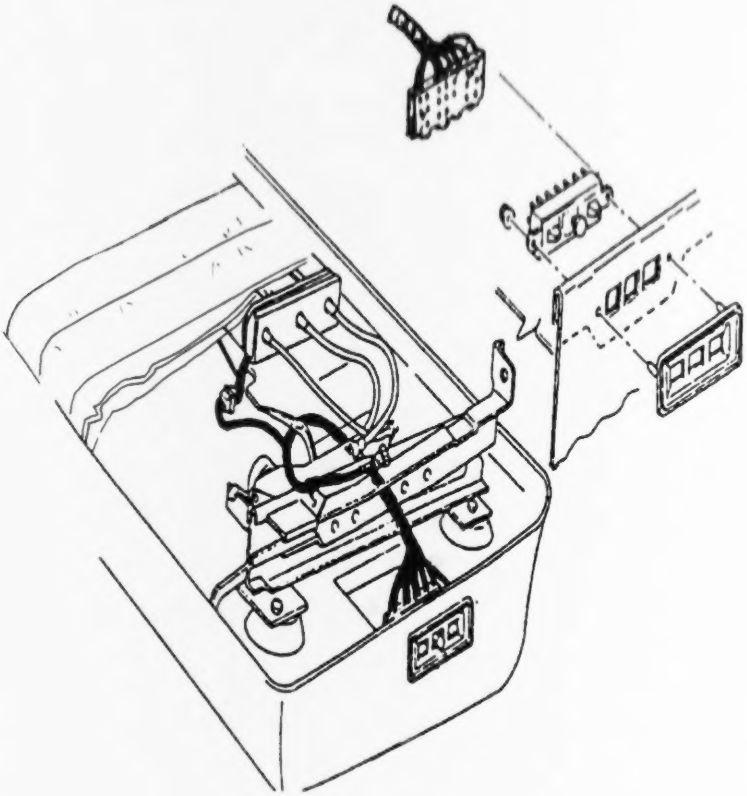
   a. An automotive power antenna is controlled by the off/on radio control knob. An electric drive motor raises the antenna until a contact switch automatically opens and stops the motor. The motor is reversed to lower the antenna.



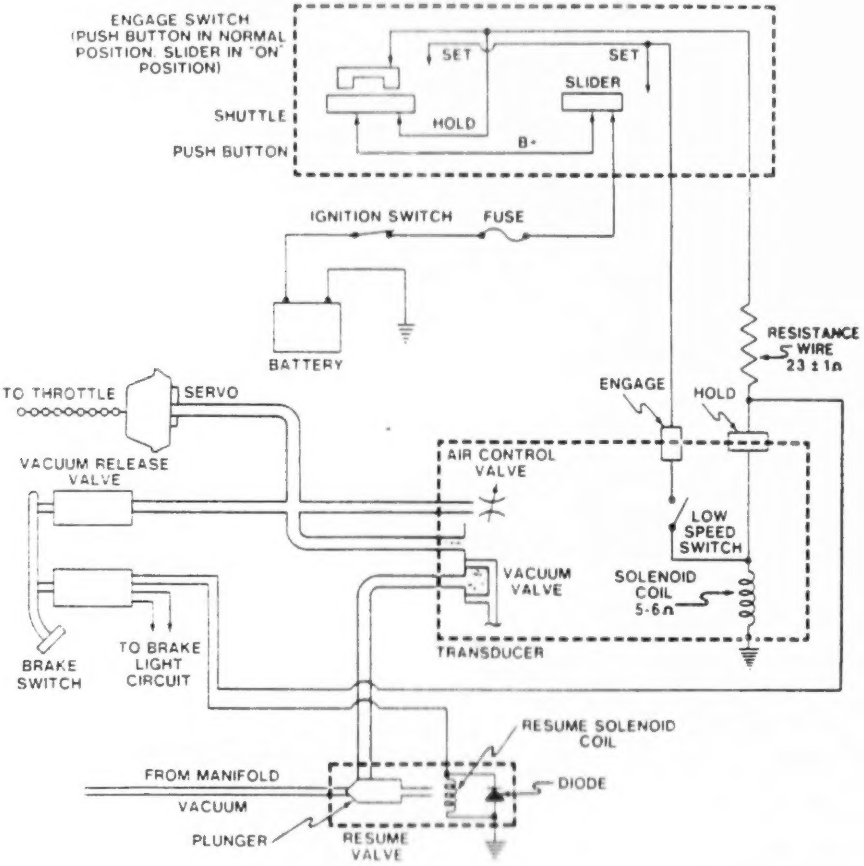
b. A contact switch activates vehicle power windows and sun roof. A reversible motor drives a gear train that moves either a linkage or a flexible drive rack, which, in turn, raises and lowers the windows and opens or closes the sun roof.



c. A contact switch activates vehicle power seats. A reversible motor drives either a worm or screw rack, which changes seat position and angle. The motor may be connected to the worm by a flexible drive shaft.



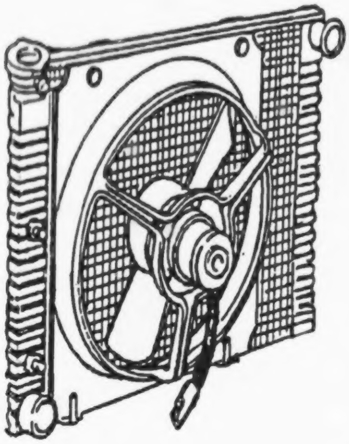
d. Some cruise control servos are motor driven. The cruise control electronic module activates a standard reversible motor. The cable is, in turn, connected to the throttle linkage. The motor winds the cable in and out to control throttle position.


ENGAGE SWITCH (PUSH BUTTON IN NORMAL POSITION, SLIDER IN "ON" POSITION)
SET
SET
SLIDER
SHUTTLE
HOLD
PUSH BUTTON
B+
IGNITION SWITCH
FUSE
BATTERY
RESISTANCE WIRE 23 ± 1Ω
TO THROTTLE
SERVO
ENGAGE
HOLD
VACUUM RELEASE VALVE
AIR CONTROL VALVE
LOW SPEED SWITCH
VACUUM VALVE
SOLENOID COIL 5-6Ω
BRAKE SWITCH
TO BRAKE LIGHT CIRCUIT
TRANSDUCER
RESUME SOLENOID COIL
FROM MANIFOLD
VACUUM
DIODE
PLUNGER
RESUME VALVE

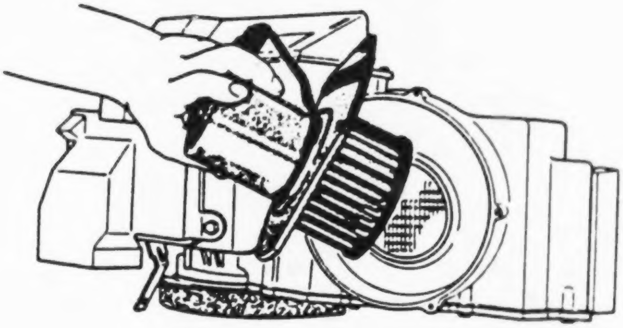
Courtesy of General Motors Corporation

2. In automobiles, motor-driven blowers use single or multiple-speed electrical motors. These motors drive impeller or squirrel cage blowers, which move air in a specific direction. Uses of these motors are discussed below.

    a. The engine coolant fan usually uses a single-speed electric motor. The motor is connected to a fan impeller, which draws air across the engine radiator. The motor is usually relay controlled and activated by a coolant-temperature sensor or any number of special subsystems requiring specific engine cooling (such as air conditioning).



    b. The heater blower uses a variable-speed motor. The motor drives a squirrel cage fan which forces air through the heater core or air conditioning evaporator core. Either a relay or a contact switch activates the motor.



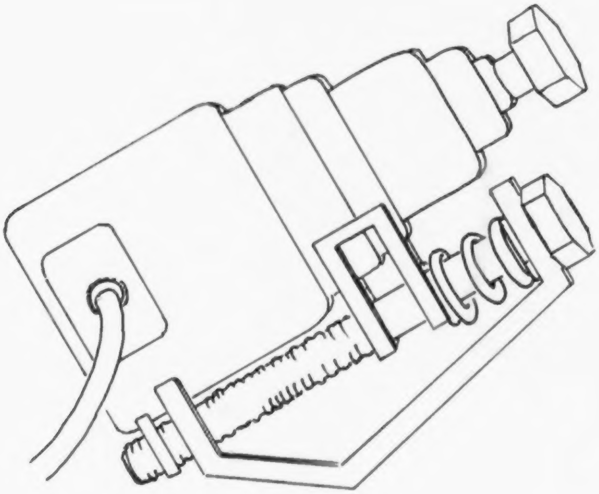
Courtesy of Chrysler Motors

C. Solenoid activator

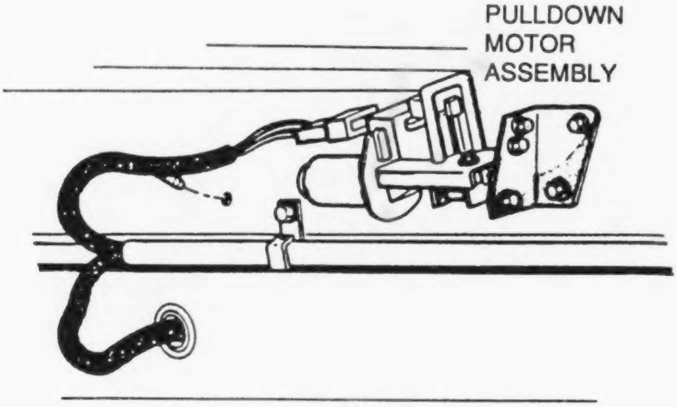
(NOTE: The following is a general description of solenoid activators. Design of solenoid activators may vary, depending upon the model of vehicle in which they are found.)

1. A single-cycle solenoid converts electrical energy into linear mechanical movement. A single-cycle solenoid is characterized by having only two positions: relaxed or fully extended (there is no middle position.)

   a. A throttle kicker solenoid is used to adjust throttle position. The kicker moves a linkage, which opens the throttle. The kicker can be activated by the air conditioning or ignition switch, by rapid power steering movement, or by an engine coolant sensor. The kicker can only be relaxed or fully extended when energized.

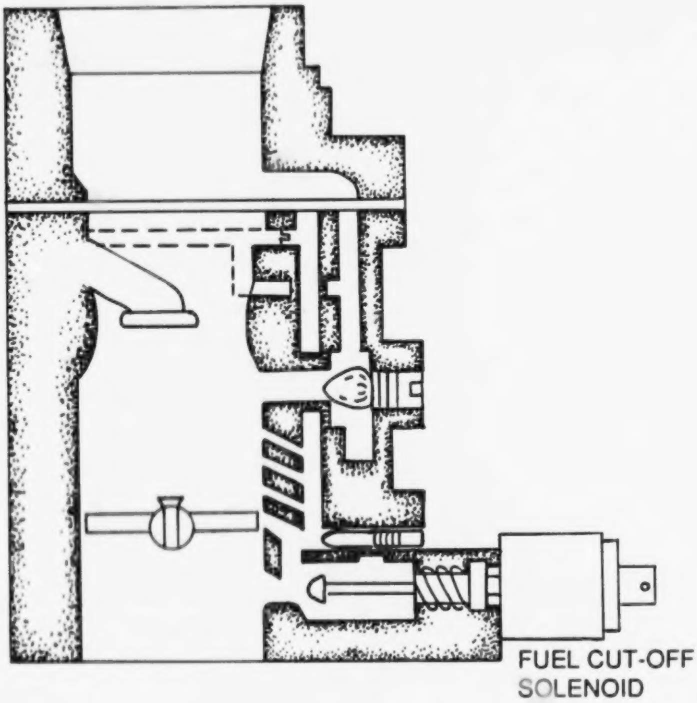


   b. The automatic trunk lid release uses a single-cycle solenoid that activates the trunk release mechanism. The solenoid is returned to its original position by spring action.



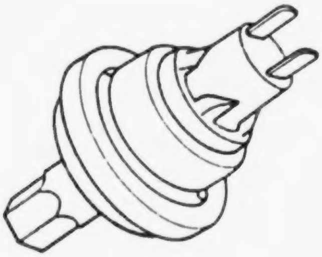
Courtesy of Chrysler Motors

c. The fuel cutoff solenoid is a single-cycle device that opens the fuel supply circuit while the engine is running. When the engine is shut off, the solenoid de-energizes, allowing the fuel port to close as a result of spring tension. The closing of the fuel port prevents engine run-on.

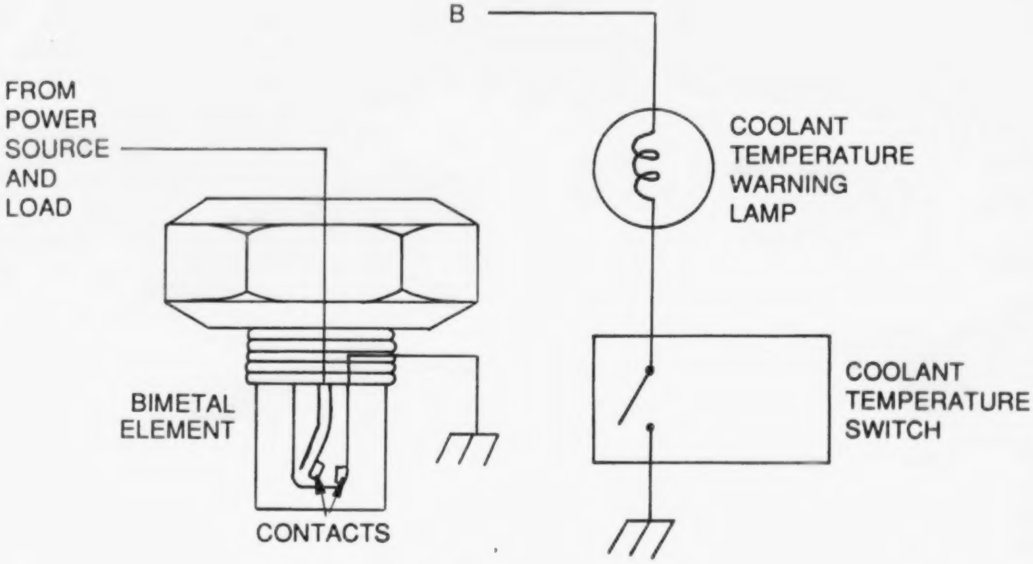


D. Cycling switch

1. Most air conditioning systems use a cycling clutch pressure unit. In a cycling orifice tube air conditioning system, clutch cycling pressure unit measures system pressure to determine how long the compressor runs. When the pressure is high, the contacts in the sending unit open and the compressor is shut off. When the pressure is low, the contacts in the sending unit close and the compressor is turned on. The cycling clutch sending unit measures the lack of pressure and responds by engaging the compressor clutch relay.



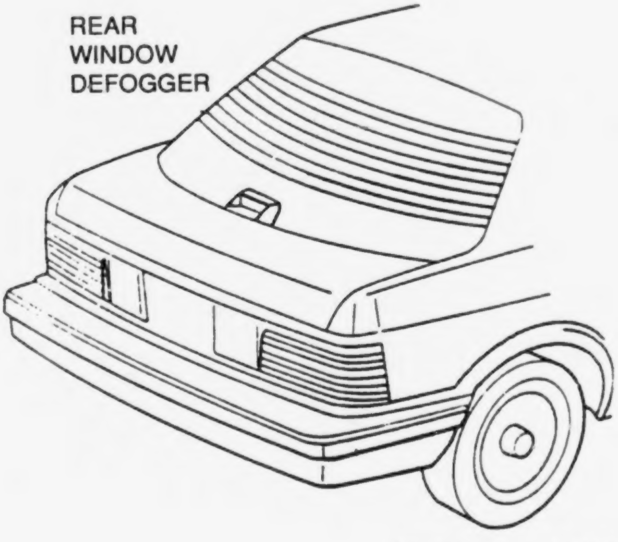
2. The engine overheat warning lamp is activated by a switching/sending unit. When the engine coolant becomes too hot, a bimetal strip in the temperature sensor expands and grounds the warning lamp circuit, thus activating an indicator light in the passenger compartment.


B
FROM POWER SOURCE AND LOAD
COOLANT TEMPERATURE WARNING LAMP
BIMETAL ELEMENT
CONTACTS
COOLANT TEMPERATURE SWITCH

E. The electrical heater (or resistant heater) uses a resistant circuit to produce heat. This heat can perform a variety of tasks in the automobile, such as defrosting windows, warming the carburetor choke, or heating an oxygen sensor.

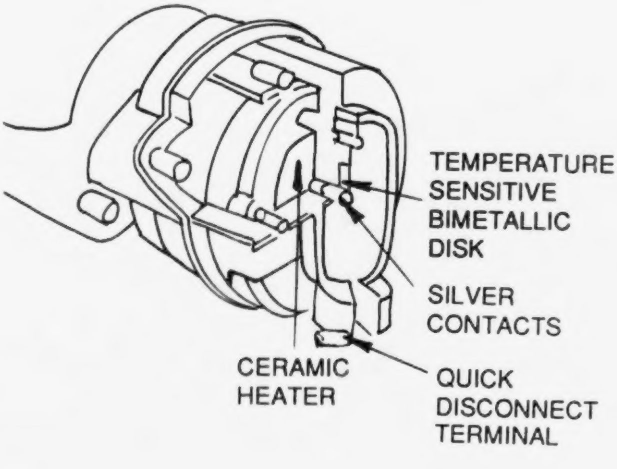
(NOTE: The following is a general description of automotive electrical heaters. Some characteristics of electrical heaters may vary, depending upon the model of vehicle.)

1. In an automobile, a window deicer is a thin, film resistance heater, bonded to a glass surface. When a control circuit is energized, current flows into the heater causing the surrounding glass to warm. The circuit is usually relay controlled.


REAR
WINDOW
DEFOGGER

Courtesy of Chrysler Motors

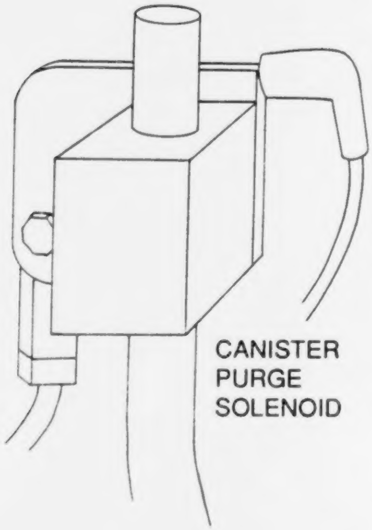
2. A choke heater is a small resistance heater located in the choke housing cover. Current is provided to the heater by a wire connected to the alternator's stator winding. When the alternator's charging rate is high, the heater is warmed more rapidly, relaxing the choke coil and thus opening the choke. Charging rate is highest immediately after the engine is started.


TEMPERATURE
SENSITIVE
BIMETALLIC
DISK
SILVER
CONTACTS
CERAMIC
HEATER
QUICK
DISCONNECT
TERMINAL

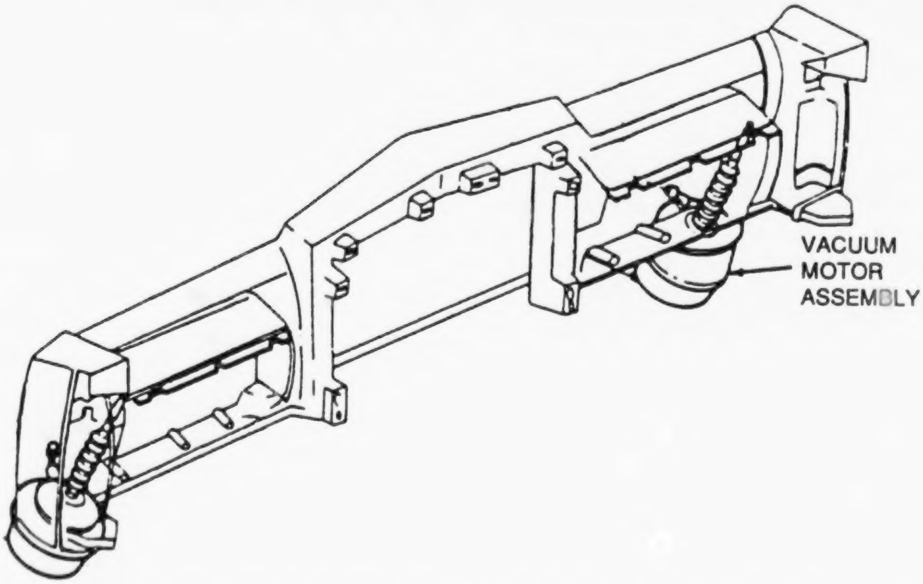
F. A transducer is a type of sensor that uses one type of energy to control another type of energy. Below are examples of how transducers are used in an automobile.

1. In a vacuum servo-type cruise control, a speed transducer converts drive shaft movement into an electrical signal. This signal opens or closes a vacuum orifice that is connected to a vacuum servo. The engine's throttle position is, therefore, controlled by the relationship between drive shaft speed and the vacuum orifice opening.

2. The canister purge solenoid uses linear motion to control the flow of fuel vapors. Therefore, this solenoid is a type of transducer. Vapor from the vehicle's fuel tank is drawn to the intake manifold during certain periods of engine operation. The canister purge solenoid allows or prohibits this circulation by venting a charcoal canister.



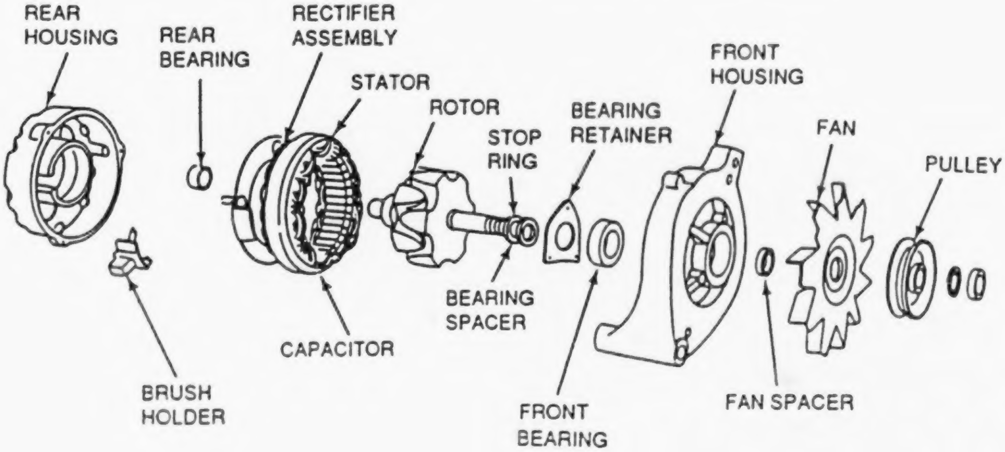
3. The concealed headlight vacuum transducer uses a vacuum servo (motor) to open the concealed headlight doors. This transducer, which is electrically controlled, allows a vacuum to pull the headlight doors open.


VACUUM
MOTOR
ASSEMBLY

G. Current-generating devices (alternators and ignition coils) produce large amounts of current or voltage. These devices produce current by one of three methods: electromagnetism, potential difference, or piezo crystal activity.

(NOTE: Electromagnetism has been covered in other units of this module and will receive only brief mention here.)

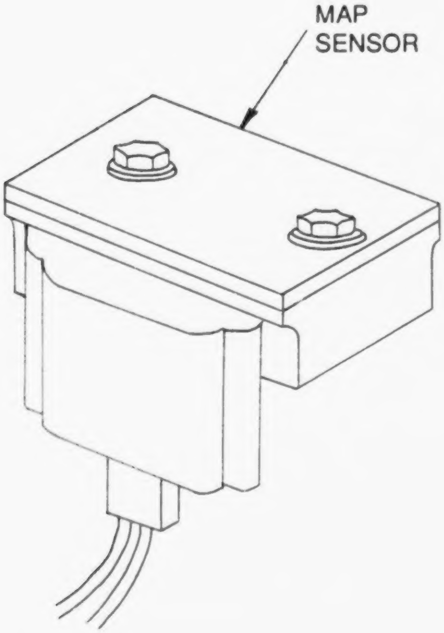
1. The alternator uses a magnetic field rotating inside a group of conductors (stator) to affect current output for the charging and battery system.


REAR HOUSING
REAR BEARING
RECTIFIER ASSEMBLY
STATOR
ROTOR
STOP RING
BEARING RETAINER
FRONT HOUSING
FAN
PULLEY
BEARING SPACER
CAPACITOR
BRUSH HOLDER
FRONT BEARING
FAN SPACER

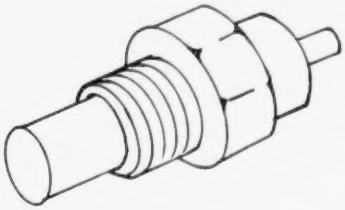
2. The ignition coil uses 4 to 5 amps of current (at battery voltage) to produce a maximum of 50,0000 volts. By using electromagnetism, the ignition coil raises the relatively low voltage of the vehicle's electrical system to a level high enough to fire the engine's spark plugs.

3. A piezo crystal will produce a small amount of current when placed in series with an appropriate circuit. A Piezo crystals produces current when bent or vibrated. Piezo crystals are useful as manifold absolute pressure sensors (MAPS) and detonation sensors.

   a. The MAPS sensor uses a diaphragm connected to one end of a crystal. Fluxing of the intake vacuum moves the diaphragm and causes it to vibrate the crystal, thus producing voltage. The engine computer senses this voltage and adjusts the engine accordingly.



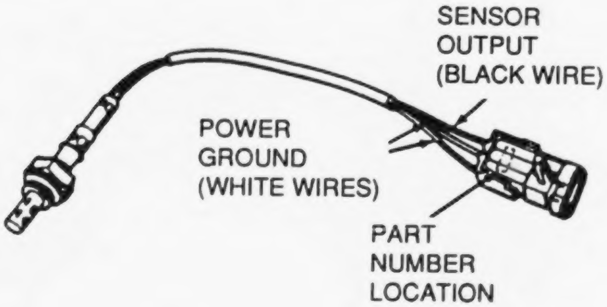
b. The detonation sensor uses shock waves produced by combustion detonation to vibrate the crystal, thus producing voltage. The engine computer senses this voltage and adjusts the engine accordingly.



4. A potential difference device places more free electrons on one side of a circuit than the other. Free electrons (current), therefore, flow from one side of the circuit to the other.

   a. The battery (which has been discussed in Unit IV of this module) is a potential difference device.

   b. The oxygen sensor is a potential difference device.

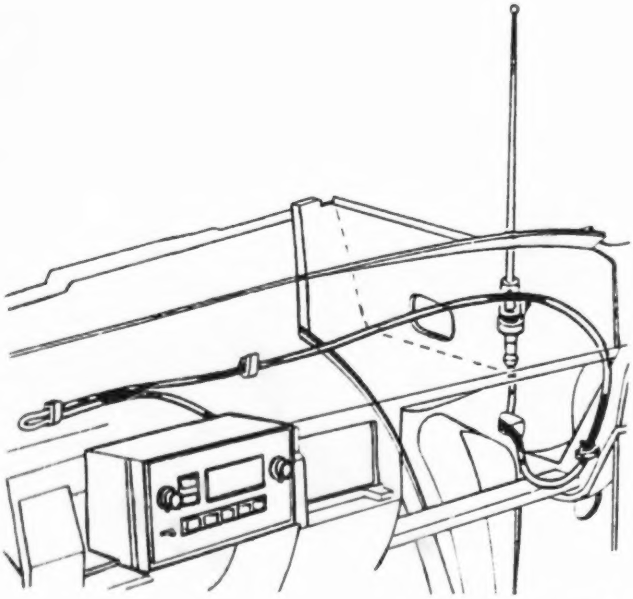

SENSOR
OUTPUT
(BLACK WIRE)
POWER
GROUND
(WHITE WIRES)
PART
NUMBER
LOCATION

Courtesy of Chrysler Motors

H. Vehicle sound systems produce sounds ranging from music to harsh warning signals. Vehicle sound systems usually involve complex electronic subsystems, which most automotive technicians are unqualified to repair. The automotive technician, however, should be qualified to repair the external circuits of these systems.

1. Entertainment system components (radios, tape players, etc.)

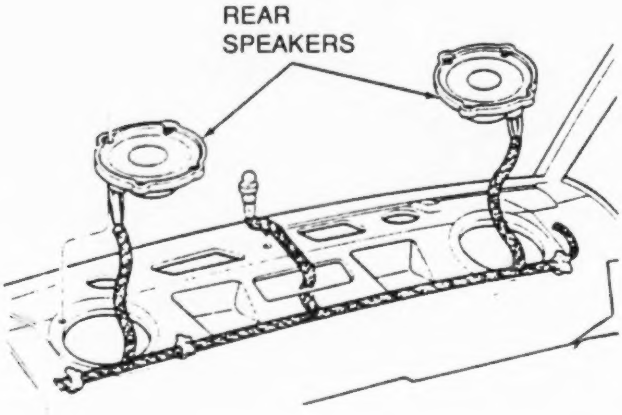
   a. The automotive radio uses fused battery current. The radio's external circuits include the power supply circuit, the antenna circuit and the speaker system circuit.

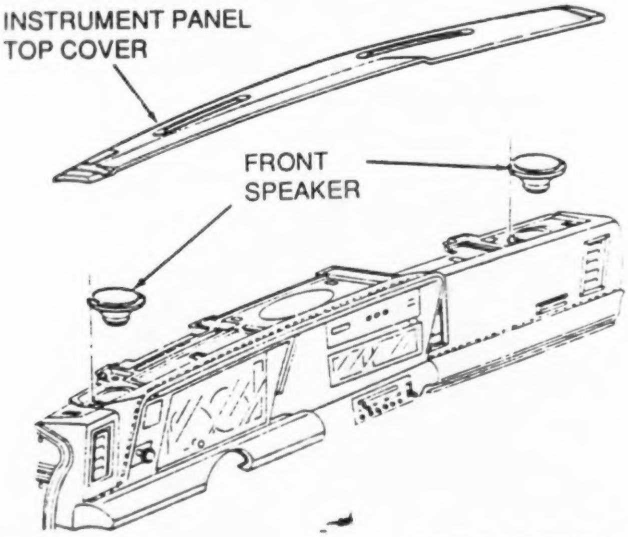


Courtesy of Chrysler Motors

   b. The AM-FM antenna is a shielded circuit, meaning that the conductor is wrapped in a braided coaxial to protect it from radio interference.

c. An automotive sound system may have from one to six speakers. The radio or tape player delivers a frequency signal (low voltage) to the speaker. (The speaker is an electromagnet connected to a diaphragm.) As the frequency signal reaches the electromagnet, it vibrates the diaphragm, thus producing sound.


REAR
SPEAKERS


INSTRUMENT PANEL
TOP COVER
FRONT
SPEAKER

Courtesy of Chrysler Motors

MODULE: ELECTRICAL SYSTEMS

UNIT XIV MISCELLANEOUS ACCESSORIES

LESSON 2: DIAGNOSING AND TESTING AUTOMOTIVE ACCESSORY CIRCUITS

I. Typical accessory circuit design and testing

A. Motor-driven accessory circuits

1. In the power antenna, the motor portion of the circuit is tested using the same procedure as for a load device. Determine the ampere rating of the circuit fuse and, using Ohm's Law, calculate the lowest acceptable resistance.

2. To test the power window and sun roof motor, use the same procedure as for testing the power antenna motor. Test the switch according to the procedure used for a control device.

(NOTE: The power window master switch controls a variety of accessory motors and is thus very complex. Each section of the master switch is the same as the individual door switch.)

3. The procedure for testing the controls and motors of the power seat is the same as any test procedure for any control or motor. Linkage or cable operation must be visually inspected for damage or binding.

4. Resistance test the cooling fan sending unit with a high-range ohmmeter. Specifications can be found in an appropriate service manual. The cooling fan motor should be resistance tested in the same manner as any other electric motor. If the system uses a power relay, use a jumper wire to test the coil and controls.

B. Solenoid activators are load devices. The solenoid activators should be tested with an ohmmeter hooked in series to the windings.

1. The electric trunk lock system uses a solenoid. The solenoid should have some resistance (but not infinite resistance). The system control switch should be checked for continuity.

2. The electronic fuel injector incorporates a solenoid which opens and closes the fuel orifice. An ohmmeter is used to resistance test the fuel injector.

(NOTE: Some fuel injectors must be tested with a fuel-injector tester.)

C. Testing the sending unit

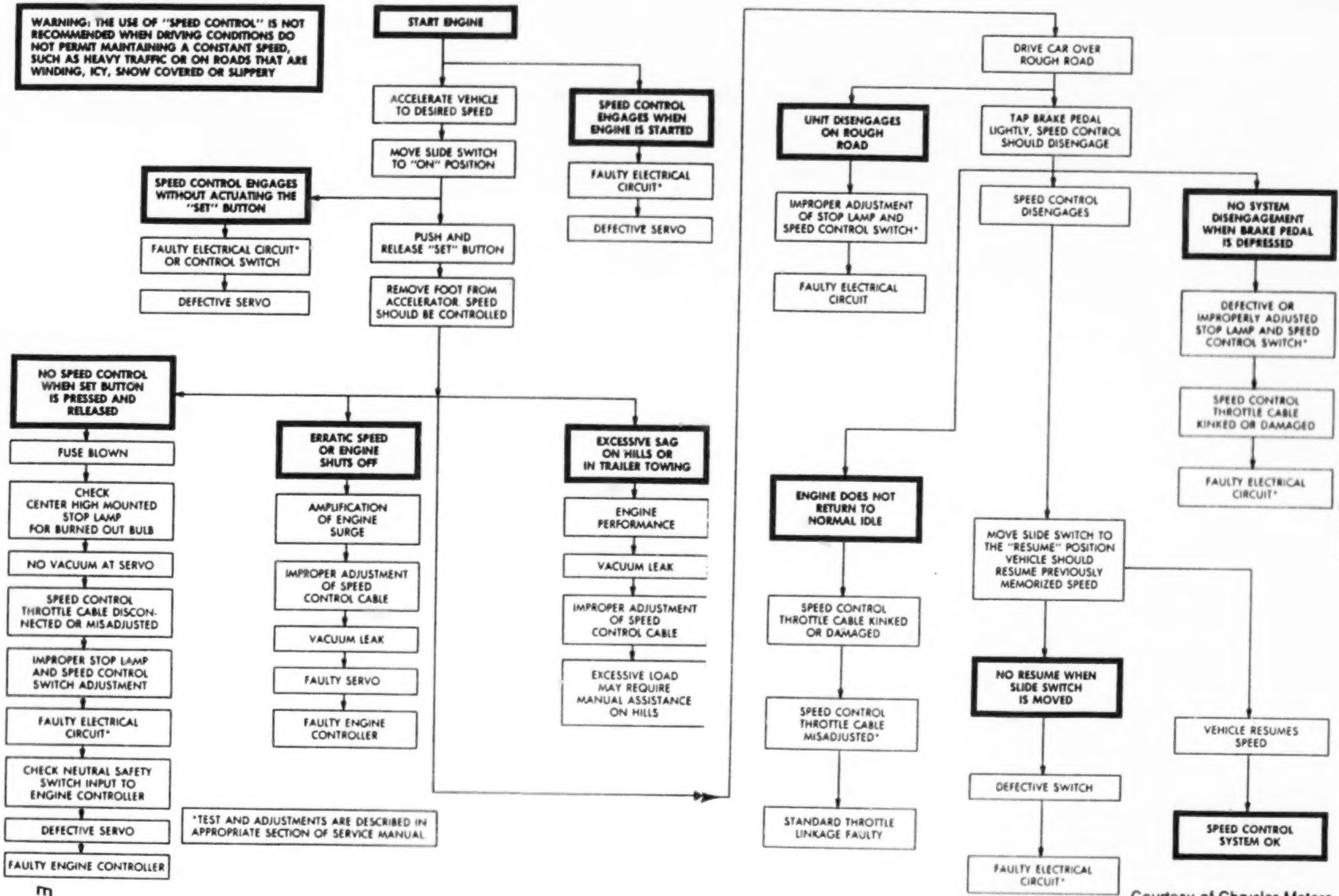
1. The throttle position sensor can be resistance tested with an ohmmeter. The sensor can be tested by measuring the resistance from the input terminal to the ground terminal and from the input terminal to the signal terminal. Move the sensor lever throughout its range. The range should be within the manufacturer's specifications and show steady rise and fall with the lever movement. The sensor usually has a narrow range of acceptable resistance. Consult the service manual for precise specifications.

2. The door-ajar warning lamp uses a grounding switch at each door. When a door is open, the door switch achieves continuity and the warning light comes on. A continuity test will determine if the bulb is operating properly.

D. The window deicer (electric window defogger) is a load device. A resistance test will determine continuity in the deicer. If the system uses a power relay, use a jumper wire to test the coil and controls.

E. In the cruise control, the junction between vacuum and electrical control occurs at the transducer. External electrical circuits control the relationship between the vacuum source and the speed of the vehicle's drive shaft. The speedometer cable drives a rate sensor that controls the position of an electromagnetic servo valve. The servo valve admits or denies vacuum to the vacuum servo. A linkage connects the vacuum servo to the carburetor throttle plate.

F. Electronic speed control trouble shooting chart


START ENGINE
ACCELERATE VEHICLE TO DESIRED SPEED
MOVE SLIDE SWITCH TO "ON" POSITION
PUSH AND RELEASE "SET" BUTTON
REMOVE FOOT FROM ACCELERATOR. SPEED SHOULD BE CONTROLLED
SPEED CONTROL ENGAGES WITHOUT ACTUATING THE "SET" BUTTON
FAULTY ELECTRICAL CIRCUIT* OR CONTROL SWITCH
DEFECTIVE SERVO
SPEED CONTROL ENGAGES WHEN ENGINE IS STARTED
FAULTY ELECTRICAL CIRCUIT*
DEFECTIVE SERVO
NO SPEED CONTROL WHEN SET BUTTON IS PRESSED AND RELEASED
FUSE BLOWN
CHECK CENTER HIGH MOUNTED STOP LAMP FOR BURNED OUT BULB
NO VACUUM AT SERVO
SPEED CONTROL THROTTLE CABLE DISCONNECTED OR MISADJUSTED
IMPROPER STOP LAMP AND SPEED CONTROL SWITCH ADJUSTMENT
FAULTY ELECTRICAL CIRCUIT*
CHECK NEUTRAL SAFETY SWITCH INPUT TO ENGINE CONTROLLER
DEFECTIVE SERVO
FAULTY ENGINE CONTROLLER
ERRATIC SPEED OR ENGINE SHUTS OFF
AMPLIFICATION OF ENGINE SURGE
IMPROPER ADJUSTMENT OF SPEED CONTROL CABLE
VACUUM LEAK
FAULTY SERVO
FAULTY ENGINE CONTROLLER
EXCESSIVE SAG ON HILLS OR IN TRAILER TOWING
ENGINE PERFORMANCE
VACUUM LEAK
IMPROPER ADJUSTMENT OF SPEED CONTROL CABLE
EXCESSIVE LOAD MAY REQUIRE MANUAL ASSISTANCE ON HILLS
DRIVE CAR OVER ROUGH ROAD
UNIT DISENGAGES ON ROUGH ROAD
IMPROPER ADJUSTMENT OF STOP LAMP AND SPEED CONTROL SWITCH*
FAULTY ELECTRICAL CIRCUIT
TAP BRAKE PEDAL LIGHTLY, SPEED CONTROL SHOULD DISENGAGE
SPEED CONTROL DISENGAGES
NO SYSTEM DISENGAGEMENT WHEN BRAKE PEDAL IS DEPRESSED
DEFECTIVE OR IMPROPERLY ADJUSTED STOP LAMP AND SPEED CONTROL SWITCH*
SPEED CONTROL THROTTLE CABLE KINKED OR DAMAGED
FAULTY ELECTRICAL CIRCUIT*
ENGINE DOES NOT RETURN TO NORMAL IDLE
SPEED CONTROL THROTTLE CABLE KINKED OR DAMAGED
SPEED CONTROL THROTTLE CABLE MISADJUSTED*
STANDARD THROTTLE LINKAGE FAULTY
MOVE SLIDE SWITCH TO THE "RESUME" POSITION VEHICLE SHOULD RESUME PREVIOUSLY MEMORIZED SPEED
NO RESUME WHEN SLIDE SWITCH IS MOVED
DEFECTIVE SWITCH
FAULTY ELECTRICAL CIRCUIT*
VEHICLE RESUMES SPEED
SPEED CONTROL SYSTEM OK

WARNING: THE USE OF "SPEED CONTROL" IS NOT RECOMMENDED WHEN DRIVING CONDITIONS DO NOT PERMIT MAINTAINING A CONSTANT SPEED, SUCH AS HEAVY TRAFFIC OR ON ROADS THAT ARE WINDING, ICY, SNOW COVERED OR SLIPPERY

*TEST AND ADJUSTMENTS ARE DESCRIBED IN APPROPRIATE SECTION OF SERVICE MANUAL

Courtesy of Chrysler Motors

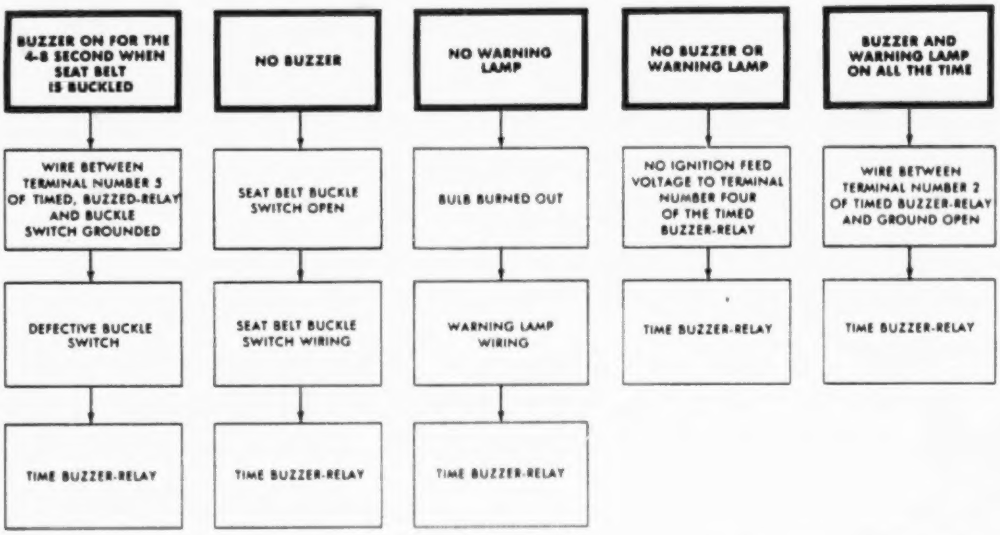
ES 591

G. Sound systems

1. Speaker wires should be resistance tested for continuity. Wire resistance should be "0". Resistance test the speaker as a load. The speaker should show some resistance but not infinite resistance.

2. In the seat belt warning buzzer system, an automatic timer is energized when the key is turned on. The timer turns on a dash warning light and an electromechanical or electronic tone buzzer. When approximately 10 seconds has passed, the timer opens the circuit until the next key cycle.

H. Seat belt warning system trouble shooting chart


BUZZER ON FOR THE 4-8 SECOND WHEN SEAT BELT IS BUCKLED
WIRE BETWEEN TERMINAL NUMBER 5 OF TIMED, BUZZED-RELAY AND BUCKLE SWITCH GROUNDED
DEFECTIVE BUCKLE SWITCH
TIME BUZZER-RELAY
NO BUZZER
SEAT BELT BUCKLE SWITCH OPEN
SEAT BELT BUCKLE SWITCH WIRING
TIME BUZZER-RELAY
NO WARNING LAMP
BULB BURNED OUT
WARNING LAMP WIRING
TIME BUZZER-RELAY
NO BUZZER OR WARNING LAMP
NO IGNITION FEED VOLTAGE TO TERMINAL NUMBER FOUR OF THE TIMED BUZZER-RELAY
TIME BUZZER-RELAY
BUZZER AND WARNING LAMP ON ALL THE TIME
WIRE BETWEEN TERMINAL NUMBER 2 OF TIMED BUZZER-RELAY AND GROUND OPEN
TIME BUZZER-RELAY

Courtesy of Chrysler Motors

AS1-L2-UXIV

MODULE: ELECTRICAL SYSTEMS

PROCEDURE FOR TESTING THE RADIATOR COOLING FAN AND ITS CIRCUIT

Instructions: **Do the tasks listed below on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for testing the vehicle's radiator cooling fan.
3. Determine and record the location of the relay that controls the vehicle's radiator cooling fan.
4. Develop a written procedure for testing the relay that controls the radiator cooling fan.
5. Determine and record the location of the sending unit that cycles the radiator cooling fan relay on and off.
6. Develop a written procedure for testing the sending unit that cycles the radiator cooling fan relay on and off.

MODULE: ELECTRICAL SYSTEMS

PROCEDURE FOR TESTING THE HEATER FAN MOTOR AND ITS CIRCUIT

Instructions: Do the tasks listed below on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for testing the vehicle's heater fan motor.
3. Determine and record the location of the relay that controls the heater fan motor's high-speed relay.
4. Develop a written procedure for exposing the heater fan motor switch so that it can be tested.

MODULE: ELECTRICAL SYSTEMS

TESTING AND SERVICING THE RADIATOR COOLING FAN AND ITS CIRCUIT

Equipment:

Hand tools
Voltmeter
Ohmmeter
Test light
Serviceable vehicle
Safety glasses

Procedure:

Step		Evaluation 3 2 1 N
1.	Wear safety glasses while doing all procedures on this job sheet.	_ _ _ _
2.	Following the procedure outlined below, determine if the vehicle's radiator cooling fan has a source of voltage.	_ _ _ _

a. Check for voltage in the circuit or circuits that supply current to the radiator cooling fan.

(HINT: Use an appropriate service manual to locate the fuses; then, check them with a test light.)

Does the circuit(s) have voltage?

Yes _ No _

b. Recommend steps to correct any circuit(s) that has no voltage.

Step		Evaluation 3 2 1 N
3.	Following the procedure outlined below, check for a defective radiator cooling fan.	_ _ _ _

a. Complete items 1 and 2 of AS1-L2-UXIV.

b. Using the procedure developed in item 2 of AS1-L2-UXIV, check the operation of the radiator cooling fan. If there is no procedure can be found for this check, use jumper wires to determine if the fan motor can be energized. Be sure to observe correct polarity. Record observations.

c. Recommend steps to correct any problems with the radiator cooling fan or related components.

4. Following the procedure outlined below, check the relay that controls the radiator cooling fan. _ _ _ _

a. Complete items 3 and 4 of AS1-L2-UXIV.

b. Following the procedure developed in item 4 of AS1-L2-UXIV, test the relay that controls the radiator cooling fan. Record observations.

c. Recommend steps to correct any problems with the cooling fan relay or related components.

5. Following the procedure outlined below, check the sending unit that cycles the radiator cooling fan relay on and off. _ _ _ _

(NOTE: On most vehicles, the radiator cooling fan is energized whenever the air conditioner comes on or when engine coolant temperature rises above the manufacturer's specified temperature--usually about 200 F.)

a. Complete items 5 and 6 of AS1-L2-UXIV.

b. Following the procedure developed in item 5 of AS1-L2-UXIV, check the cooling fan sending unit.

OK _ NOT OK _

c. Recommend steps to correct problems associated with the sending unit.

Average of above evaluations* _ _ _ _

(*This average is a partial evaluation for Competency I2. Final evaluation of I2 will be made at the end of JS3-L2-UXIV.)

MODULE: ELECTRICAL SYSTEMS

TESTING AND SERVICING THE HEATER FAN MOTOR AND ITS CIRCUIT

Equipment:

Hand tools
Voltmeter
Ohmmeter
Test light
Serviceable vehicle
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. _ _ _ _

2. Following the procedure outlined below, determine if the vehicle's heater fan (blower) motor has a source of voltage. _ _ _ _

   a. Check for voltage in the circuit or circuits that supply current to the heater fan (blower) motor.

      (HINT: Use an appropriate service manual to locate the fuses, then, check them with a test light.)

      Does the circuit(s) have voltage?

      Yes _ No _

   b. Recommend steps to correct a circuit with no voltage.

3. Following the procedure outlined below, check the vehicle's heater fan motor. _ _ _ _

   a. Complete items 1 and 2 of AS2-L2-UXIV.

   b. Using the procedure developed in item 2 of AS2-L2-UXIV, check the operation of the heater fan motor. If no procedure can be found, use jumper wires to determine if the motor can be energized. Be sure to observe correct polarity.

      OK _ NOT OK _

c. Recommend steps to correct problems with the heater fan motor or related components.

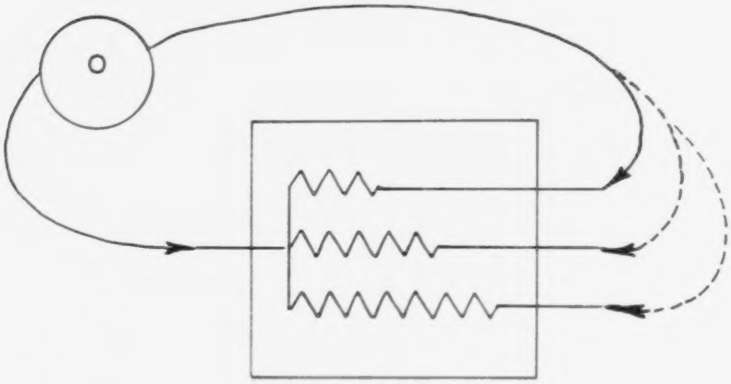
4. Following the procedure outlined below, check the heater fan motor resistor pack. _ _ _ _

(NOTE: Some vehicles do not use a resistor pack to control heater fan speed. Use an appropriate service manual to determine how fan speed is controlled in the vehicle being serviced.)

a. Locate and remove the resistor pack.

b. Connect one lead of the ohmmeter to the resistor pack's common (output) terminal.

c. Touch the ohmmeter's other lead to the input terminals and record observations.



d. Recommend steps to correct problems associated with the heater fan motor resistor pack.

5. Following the procedure outlined below, check the vehicle's high-speed heater fan relay. _ _ _ _

(NOTE: Some vehicles do not use a relay to control the high-speed heater fan. Use an appropriate service manual to determine how fan speed is controlled in the vehicle being serviced.)

a. Complete item 3 of AS2-L2-UXIV.

b. Using the procedure developed in item 3 of AS2-L2-UXIV, check the operation of the high-speed fan relay. Record observations.

c. Recommend steps to correct problems with the high-speed fan relay or related components.

6. Following the procedure outlined below, check the heater fan motor switch. _ _ _ _

a. Complete item 4 of AS2-L2-UXIV.

b. Using the procedure developed in item 4 of AS2-L2-UXIV, expose the switch so that it can be tested.

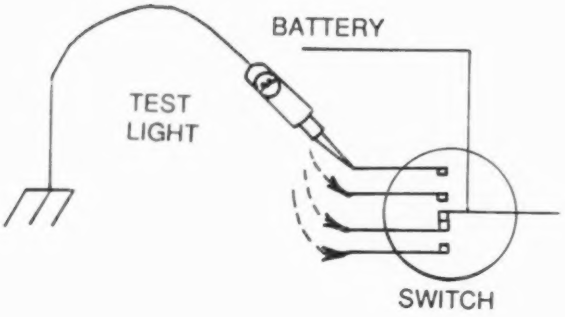
(NOTE: Do not disconnect the switch.)

c. Identify the switch's power terminal. Using a test light, determine if it has voltage. Check the appropriate blank below.

Voltage _ No voltage _

(NOTE: If the terminal has no voltage, repair the circuit before continuing.)

d. While rotating the switch through different positions, check the continuity through each of the switch legs. Record the results below.



e. Recommend steps to correct problems with the heater fan motor switch or related components.

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency I2. Final evaluation for I2 will be made at the end of JS3-L2-UXIV.)

JS3-L2-UXIV

MODULE: ELECTRICAL SYSTEMS

TESTING AND SERVICING THE RADIO CIRCUIT AND RELATED COMPONENTS

Equipment:

Hand tools
Voltmeter
Ohmmeter
Test light
Serviceable vehicle
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Following the procedure outlined below, determine if the vehicle's radio circuit has a source of voltage. __ __ __ __

   a. Check for voltage in the circuit that supplies current to the radio.

      (HINT: Use an appropriate service manual to locate the fuse. Check fuse with a test light.)

      Does the circuit have voltage?

      Yes __ No __

   b. Recommend steps to correct a circuit with no voltage.

3. Following the procedure outlined below, check the vehicle's radio speaker's for defects. __ __ __ __

   a. Connect an ohmmeter to the speaker and compare reading to manufacturer's specifications. Record the results below.

b. Connect one lead of the ohmmeter to one speaker terminal and the other to the case. Record observations.

c. Perform a sound check by touching a 9-volt battery to both ends of the speaker. The speaker should make a crackling sound. Record whether or not the speakers are working properly.

d. Recommend steps to correct any problems with the speakers.

4. Following the procedure outlined below, check the radio antenna. — — — —

a. Unplug the antenna from the back of the radio.

b. Using an ohmmeter, check the items listed on the chart below.

(NOTE: Only one design must be tested.)

Fender mount design			
Circuits	Specification	OK	NOT OK
Mast to center terminal	Low		
Center terminal to casing	High		
Casing to mast	High		
Mast to ground	High		
Center terminal to ground	High		
Casing to ground	Low		

Built into windshield design			
Circuits	Specification	OK	NOT OK
Casing to center terminal	High		
Casing to ground	High		
Center terminal to ground	High		

c. According to the above test, the circuit is:

OK _ NOT OK _

d. Recommend steps to correct any problems with the circuit or related components.

Average of above evaluations* _ _ _ _

(*This average is a partial evaluation for Competency I2. Final evaluation for I2 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency I2 by averaging the final evaluation of JS1-L1-UXIII, JS2-L1-UXIII, JS3-L1-UXIII, JS1-L2-UXIV, JS2-L2-UXIV, and JS3-L2-UXIV. Use the spaces provided below.

	Evaluation 3	 2	 1	 N
JS1-L1-UXIII	___	___	___	___
JS2-L1-UXIII	___	___	___	___
JS3-L1-UXIII	___	___	___	___
JS1-L2-UXIV	___	___	___	___
JS2-L2-UXIV	___	___	___	___
JS3-L2-UXIV	___	___	___	___
Final evaluation for Competency I2	___	___	___	___

MODULE: ELECTRICAL SYSTEMS

UNIT XIV: MISCELLANEOUS ACCESSORIES

UNIT XIV TEST

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 1. The cruise control system can be either an electromechanical or electropnuematic system.

____ 2. An electropnuematic system converts an electrical signal into a vacuum, into air pressure, or into fluid activity or vice versa.

____ 3. Power seats use a gear box to control seat position and seat attitude.

____ 4. Motor-driven accessory devices primarily use AC current motors.

____ 5. In accessory systems, the function of the sending unit is to control magnetic fields.

____ 6. The main function of a solenoid activator is to convert electrical energy into heat energy.

____ 7. The motor-driven gear box is basically a load device.

____ 8. The power antenna is activated by an on/off radio control knob.

____ 9. The power window and motors are activated by a relay switch.

____ 10. Power seats are activated by a relay switch.

____ 11. Some cruise control servos are motor driven.

____ 12. The engine coolant fan usually uses a multiple-speed electric motor.

____ 13. The heater blower uses a single-speed electric motor.

____ 14. A single-cycle solenoid is characterized by having only two positions: relaxed and fully energized.

____ 15. Manifold absolute pressure sensors (maps) are variable control sending units.

____ 16. A switching/sending unit measures the range of a condition.

____ 17. The air conditioning clutch cycling pressure unit is actually a manifold absolute pressure sensor (maps).

____ 18. In detonation sensors, the crystal is vibrated by the movement of an armature.

SECTION B. Select the best answer from the five choices listed.

___ 19. A typical application of the motor-driven gear box is

a. the power antenna.
b. power windows.
c. power seats.
d. all of the above.
e. none of the above.

___ 20. The throttle kicker is a solenoid that is used to adjust throttle position by

a. holding the linkage in a more open position when the solenoid is energized.
b. holding the linkage in the closed position when the solenoid is energized.
c. causing rapid movement of the linkage when the solenoid is energized.
d. causing the linkage to rotate when the solenoid is energized.
e. none of the above.

___ 21. The automatic trunk lid release system uses

a. a multiple-cycle solenoid.
b. a single-cycle solenoid.
c. either a multiple or single-cycle solenoid.
d. both a multiple and single-cycle solenoid at the same time.
e. no solenoid.

___ 22. The sending unit works to

a. activate a circuit.
b. deactivate a circuit.
c. modify the activity of a circuit.
d. do all of the above.
e. do none of the above.

___ 23. A window deicer is usually

a. an electric heater and fan that blows warm air onto the glass surface.
b. a pump and a series of hoses and nozzles that spray deicing chemicals onto the glass surface.
c. a special type of glass that produces heat when a current passes through it.
d. a series of transparent wires running through the glass.
e. none of the above.

___ 24. A choke heater is a small resistance heater

a. attached to the outside of the choke housing.
b. connected to wires leading to the choke housing.
c. placed in the cover of the choke housing.
d. surrounding the choke housing.
e. none of the above.

____ 25. The canister purge solenoid controls

a. air flow.
b. coolant temperature.
c. engine oil pressure.
d. engine oil temperature.
e. alternator output.

____ 26. In order to open the headlight door, the concealed headlight vacuum switch uses

a. a vacuum servo.
b. a linear solenoid.
c. a sending unit.
d. a switching/sending unit.
e. an electronic relay.

____ 27. Current or voltage-generating devices produce current through

a. electromagnetism.
b. potential difference.
c. the use of a piezo crystal.
d. all of the above.
e. none of the above.

SECTION C. **Read each of the below statements made by technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.**

____ 28. Technician I says that the motor portion of the power antenna circuit can be tested with the same procedure that is used to test a control device.

Technician II says that the procedure for testing the control and motor parts of the power seat is the same as the procedure for testing a control device.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 29. Technician I says that the sending unit in the cooling fan circuit should be tested with a low-range ohmmeter.

Technician II says that solenoid activators should be tested with an ohmmeter hooked in series to the windings.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 30. Technician I says that, if the seat belt warning buzzer remains on for 4-8 seconds after the seat belt is buckled, the seat belt buckle switch could be open.

Technician II says that faulty wiring in the seat belt buckle switch could cause the seat belt warning buzzer to fail.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 31. Technician I says that a faulty time buzzer-relay could cause a seat belt warning lamp to fail.

Technician II says that a faulty time buzzer-relay could cause a seat belt buzzer and warning lamp to fail.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 32. Technician I says that a defective servo could cause a vehicle's electronic speed control to engage without the driver pressing the set button.

Technician II says that a vacuum lead could cause a vehicle's electronic speed control to engage when engine is started.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 33. Technician I says that amplification of engine surge can cause the speed control to fail to come on when set button is pressed and released.

Technician II says that a vacuum leak can cause the vehicle to lag on hills while the speed control is on.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 34. Technician I says that improper adjustment of a stop lamp and speed control switch can cause the speed control unit to disengage on rough road.

Technician II says that, if the speed control unit fails to disengage when the break pedal is depressed, there may be a kink in the speed control throttle cable.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of ______ on the Unit XIV Test in order to receive an evaluation for Competency 12.)

ANSWERS TO UNIT XIV TEST

1. t
2. t
3. t
4. f
5. f
6. f
7. t
8. t
9. f
10. f
11. t
12. f
13. f
14. t
15. t
16. f
17. f
18. f
19. d
20. a
21. b
22. d
23. e
24. c
25. a
26. a
27. d
28. d
29. d
30. b
31. c
32. a
33. b
34. c